JOURNAL

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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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ON KEEPING ABREAST

LAST YEAR THE INSTITUTION PUBLISHED IN ITS *Proceedings* about a hundred and thirty papers; they filled four substantial volumes, and any engineer who read and digested this or an equivalent amount of material might feel satisfied that he had done justice to the electrical engineering literature for the year. In the same period, however, *Electrical Engineering Abstracts* recorded over five thousand items; even these do not represent the total of all that was written about electrical engineering in 1954, but are a selection of the more important items from at least double their number.

What conclusions are to be drawn from this noticeable contrast? Is the literature of electrical engineering no longer manageable by the individual? Is The Institution contributing less than its proper share to the general fund of knowledge? Or, on the contrary, is the great mass of published material of so little value as to be safely ignored? An analysis of the contents of *Electrical Engineering Abstracts* does not allow any of these questions to be confidently answered. Naturally, very few of the items are of the same calibre as *Proceedings* papers; there cannot be, all told, more than about a thousand such papers each year, covering all branches of electrical science and technology. There are, however, many more smaller, detailed items—topical, controversial, or transient perhaps—which nevertheless contain a great deal of valuable matter, and it is here that The Institution's share is small and might well be augmented, although we hesitate, in view of the overwhelming bulk of electrical engineering publication at present, to recommend a further increase; but undoubtedly the opportunity which the *Journal* now offers for the publication of correspondence and short articles is one which, to judge by similar publication elsewhere, should prove of substantial value; in addition, the pages of the *Proceedings* are, as they have been for some time, open to the more specialized short paper.

A fair proportion of the items recorded in *Electrical Engineering Abstracts* is made up of descriptive reports, in foreign languages, of installations and operating experiences in other countries. Many of these are of direct interest to the consulting engineer or engineer-operator, who too often regards *Electrical Engineering Abstracts* as a happy hunting ground for the engineer-scientist only. The journals they appear in are sometimes difficult of access and often unintelligible without translation. The proportion of them that is of real technical use may often be very small. It is tempting to say that they might be ignored. Nevertheless, they represent information, always liable to have an unexpected significance in an unforeseen situation, and therefore requiring to be sorted out and recorded for future reference. The language difficulty gives the abstracts, which are in English, a further value; and no engineer is entitled to feel an insular contempt for foreign articles unless he keeps them under periodic review in at least this second-hand way.

Electrical Engineering Abstracts is largely a record of the contents of regularly appearing periodicals, a dozen or so of which are to be found in every library and electrical engineering establishment in the world, and whose exclusion might therefore be argued, were the resulting economy thought to justify the incompleteness so caused. A small informal inquiry has recently been made to probe this point, among others, and to determine possible deficiencies in the coverage of literature. Significantly enough, nearly all replies agree in asking for a greater coverage of publications outside the field of regular periodicals; publications, that is, ranging from books and carefully considered monographs, on the one

hand, to reports and memoranda which are not so much "published" as simply "released," on the other. These are the irregular sources of information with which the engineer, rather naturally, has the greatest difficulty in keeping up to date. Some of this material presents a difficult problem; in the absence of the traditional hallmarks of reliability, it is hard for the reader to distinguish the trivial and inaccurate from the genuinely important; furthermore, there seem to be few precautions taken to prevent the appearance of the same material in several different places, a practice which can be justified only if the identity is properly advertised, and this is frequently overlooked. If useful material continues to appear in this undisciplined way, there is clearly a need for its orderly collection and recording.

Opinions differ as to the cardinal importance of speed in the publication of abstracts; it is doubtful whether anyone would demand speed at the expense of accuracy or completeness, but there is no reason why they should not be combined, if it is recognized that, unavoidably, saving time costs money. This is, of course, true also of wasting time, and there is, unfortunately, some of the latter in the business of electrical engineering abstracts, through duplication of effort by independent organizations; it is hard to believe that their purposes are so different as to forbid of any reconciliation, and it must be the main target of future development to establish at least some measure of co-operation. *Electrical Engineering Abstracts* exists to serve electrical engineers of all specialities, and although its abstracting service is doubtless not perfect, the existence of independent abstracts on specialized aspects of electrical engineering does not seem justified. Abstracting is not an activity which is helped by competition; we believe that all engineering abstracting is subsidized, and that duplication of effort, rather than co-operation and, perhaps, reprinting of abstracts by the various interested bodies, is a waste of public or professional money. Abstracts are now a necessity to many engineers for keeping abreast of current developments, and it is vital to their technical proficiency that they are given the best abstracting services that present resources allow.

EUSEC Conference on Engineering Education

THE second Conference of representatives of the Engineering Societies of Western Europe and the United States of America on the education and training of professional engineers was held in Zürich from the 27th September to the 1st October, 1954.

The Conference was attended by delegates from Belgium, Denmark, Finland, France, Germany, Holland, Norway, Sweden, Switzerland, the United Kingdom, and the United States, who were chosen by the respective engineering societies in those countries to include representatives of the universities and industry.

The discussions were most useful, and, in particular, the Conference benefited greatly from hearing first-hand a comprehensive description of recent developments in engineering training in the United States, given by the members of a very representative and experienced delegation from that country.

The Conference set up two working parties: one to prepare a glossary of terms in the different languages of the member societies of EUSEC relating to engineering education and training; and a second to make comparative analyses of a student's general education in the various countries before the start of his engineering education.

A resolution was passed recommending to EUSEC that a third conference on engineering education and training should be held in Paris in September, 1956, and an Executive Committee was appointed to prepare for this conference.

All the delegates expressed great appreciation of the admirable arrangements which had been made by their Swiss hosts, not only for the business sessions of the Conference, but also for its programme of social engagements. An absorbing and picturesque rail journey took the delegates to Lausanne, where the university was visited, and there were equally notable visits to the Eidgenössische Technische Hochschule at Zürich, and to the Brown-Boveri works at Baden. Nor will the delegates forget the most impressive hospitality extended to them by the Swiss Institution and the civic authorities.

Because this second Conference was an exploratory one, its proceedings are not being published in full. Copies of the proceedings of the first Conference held in London in 1953 are still obtainable from the Secretary at a price of 15s. each, post free.

An Electrical Engineering Review

FLOOD-LIGHTING

This is a review of the present-day principles and practice of flood-lighting which approaches the subject from the engineer's standpoint yet does not forget that it is largely an art; for, as the author puts it, "a striking and satisfying result is likely to be due more to inspiration than to science." The term "flood-lighting" is defined in B.S. 233: 1953 as the "lighting, usually by projection, of the whole of a scene or object to an illumination considerably greater than that of its surroundings," and may thus cover television studios, shop windows, theatre stages, and the like. In this review, Mr. Atkinson, Technical Editor of the E.L.M.A. Lighting Service Bureau, considers only those parts of the subject implied by the term in its more popular sense, namely the lighting of exterior building surfaces and football pitches.

A. D. S. ATKINSON, *Associate Member*

1 *Stroud Church, Gloucestershire*

An example of the flat featureless effect which can be produced by flood-lighting from directly in front of a building.

A WELL-PLANNED flood-lighting installation can give such a spectacular effect that one may be inclined to suppose that the planning presents great technical difficulties, but this is very seldom true, for with many subjects—ancient buildings in particular—a striking and satisfying result is likely to be due more to inspiration than to science. As with all other applications of lighting, the success of a scheme depends on its appeal to the visual sense, and if the majority of people do not happen to like what they see, the effort and expense that have gone into producing it may be largely wasted.

Many buildings can look better when flood-lit than they do by day, for by this means their more favourable features can be emphasized and unsightly outbuildings or encroaching neighbours excluded. On the other hand, unskilful flood-lighting can make them look worse than they should, and this may well occur if no thought is given to the daylight effect of the building that was intended by the architect. It is true that flood-lighting very often reverses the high-lights and shadows of daylight, and is sometimes condemned on that score, but the effect can in fact be very attractive. What is very much more important is to avoid eliminating shadows or creating others which destroy the architectural lines of the building. A study of the subject by daylight will always help the engineer to plan the siting of his projectors, and he can be reasonably satisfied if he makes a good building look at least as attractive by night as by day. He can expect an ugly one, with luck, to look better.

Is the Building worth Lighting?

The answer to the question whether a building is worth lighting depends on a number of considerations, of which architectural merit is only one. There may of course be excellent historical, religious, political, commercial or personal reasons why it should be lighted, and even if it seems to have little or no architectural merit it can often be given interest or charm by lighting. By the imaginative use of light and shade an interesting picture can be made out of the most unpromising material; a plain brick or stone wall, for instance, will be transformed if light is thrown on to it at an angle sufficiently oblique to emphasize the irregularities of its surface. Nothing can be done to enhance the beauty of an acknowledged architectural masterpiece such as Canterbury Cathedral—the best that can be hoped for is that the beauty will not be diminished by unskilful use of light; but many dull or downright ugly buildings may have certain features which, taken singly, will redeem the rest, and clever flood-lighting can emphasize these at the expense of the dull mass.

Even though a building may not of itself seem a good flood-lighting prospect it can still look impressive, especially from a distance, and by virtue of its position can become a prominent part of a wide scene. It can also form an effective background to other unlighted structures or sculpture; the Victoria Memorial, for instance, looks well in silhouette against flood-lit Buckingham Palace.

2 *Colchester Castle*

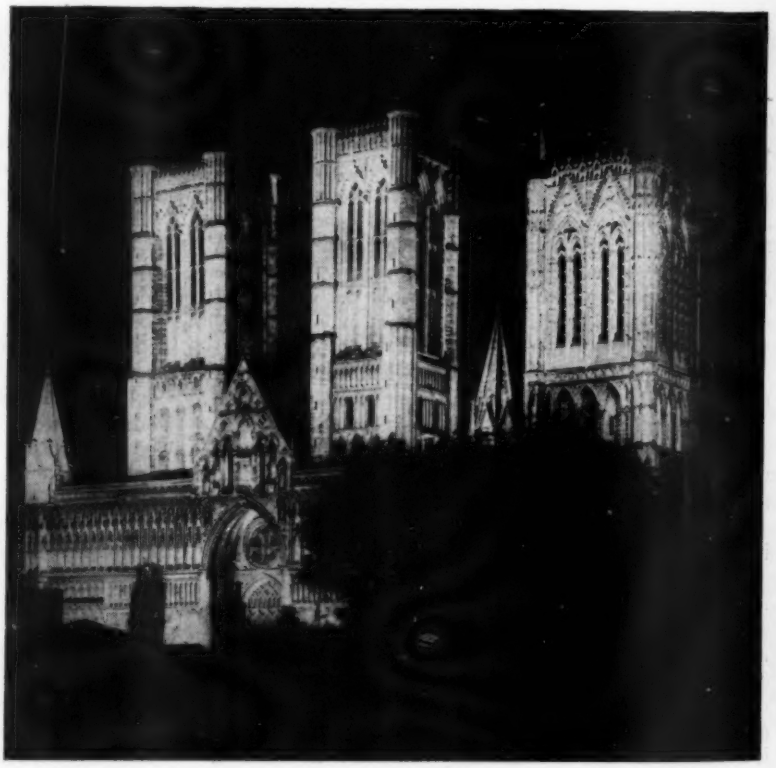
Sodium flood-lights are placed close to the wall so that the light strikes it at an oblique angle to emphasize irregularities in its surface.

Most buildings to be lighted were designed long before flood-lighting was thought of, but the interplay of light and shade must have been considered by the architect, who provided certain features to give the effects he wanted in the geographical and climatic conditions concerned. In Mediterranean countries, for example, buildings are likely to have deep overhanging eaves and shady porticos to keep them cool, and the high sun gives light and shade effects to emphasize the long horizontal lines; some vertical relief is often obtained by white columns seen against the shady porches they support. Farther north, where the sun is frequently obscured by clouds and more of the available daylight comes from a lower angle, the native style of architecture is often Gothic, in which towers and heavy buttresses give strong vertical lines and elaborate skylines to be seen against the grey sky. This is not to say that Gothic buildings have exclusively vertical lines. There will always be cornices, string courses and similar horizontal features to relieve monotony and tie the parts of the building together, but these are a subordinate part of the design, and should not be given undue emphasis. Since flood-lighting equipment is usually mounted on or near the ground, over-emphasis of horizontal lines is often difficult to avoid, and for this reason Gothic buildings in general should be lighted if possible by beams which strike the surface sideways at an oblique angle. With the classical style, light can be thrown more directly onto the building face, but some oblique light should also be provided to give vertical interest as well. Classical colonnades respond well to a complete reversal of the daylight effect; if the interior walls of the portico are lighted the columns stand out in silhouette to give a very striking effect without destroying the architectural lines.

In crowded localities the lower parts of buildings are often dull and it is only above ordinary roof level that they break out into elaborate decoration. Many of Wren's churches are typical examples. For such buildings it is not worth trying to light their lower parts, most of which would not be seen in any case, because of the

3 *Lincoln Cathedral*

In order to preserve the detail of the west front (lower left) the lighting comes predominantly from one side, with relief from the other. The towers are lighted by projectors at or near ground level, spaced around the building.



obstruction of nearby buildings; but it is frequently rewarding to light the upper parts, which will often be visible from a distance of several miles and can give a city a magnificent skyline at night.

Many modern buildings are designed to be flood-lighted, but, even where they are not, the "stepped-back" construction popular in recent years enables projectors to be placed on each step to avoid the heavy shadow which would be cast by the steps from projectors at ground level. Such shadows, which can be cast also by eaves, cornices, etc., can make the building appear to consist of a number of disconnected pieces floating one above the other, and while this is doubtless all wrong aesthetically and should not be aimed at, sometimes when it does accidentally happen the result is quite acceptable.

For at least one notable building—the Royal Festival Hall—the architects have used flood-lighting and interior lighting together to give the night-time effect they want. Here lighted windows, indirect lighting of the space beneath the auditorium, and flood-lighting of its back wall have been combined to give the effect of a glowing cube of light suspended in a glass and concrete box; whatever people's opinion of the daylight appearance of this structure, the night effect is generally agreed to be wholly delightful.

Flood-lights

The full spread of light emerging from a flood-light depends upon the size of the front opening and its position relative to the lamp, but for design purposes only the light emerging within a certain *beam spread* is regarded as being useful. The beam spread is defined as the angle subtended at the fitting by the limits of a surface, normal to the main axis of the beam, on which the illumination does not fall below one-tenth of the maximum. In a multi-lamp installation normal overlapping of the beams will give a diversity of illumination of about 2 : 1 on adjacent parts of the building surface; but the eye is very tolerant of gradual change, and even were some parts of a building to be lighted several times as brightly as other parts, the difference would not be very apparent, provided that abrupt changes in brightness were avoided. The light flux contained within this beam spread (i.e. the *beam flux*) divided by the total light output of the lamp, is termed the *beam factor*.

The spread of the beam given by a flood-light depends on the shape and nature of the reflector, and the type and position of the lamp. Theoretically a paraboloidal-mirror reflector with a "point" source of light at the focus will give a parallel projected beam, but any source of light must have a certain physical size, which means that most of the source will be slightly off focus. This and any imperfections in reflector contour will both give rise to a divergent beam, and even when projector lamps which have closely bunched filaments are used the beam spread is not likely to be smaller than about 12°. Projectors with a narrow beam (12–25°) will obviously be required for long-range lighting, for otherwise too much of the projected light would miss the object at which it was aimed.

Substitution of an ordinary general-lighting-service (g.l.s.) lamp for the projector lamp in the above type of projector will generally give a beam spread of 25–40°, which is more suitable for medium-range work, for the aiming of the beam will not be so critical, and advantage can be taken of the slight extra light output of the g.l.s. lamp. If the paraboloidal mirror is replaced by one having the same general shape but consisting of a number of flat facets, the beam spread will be still wider, up to perhaps 60°.

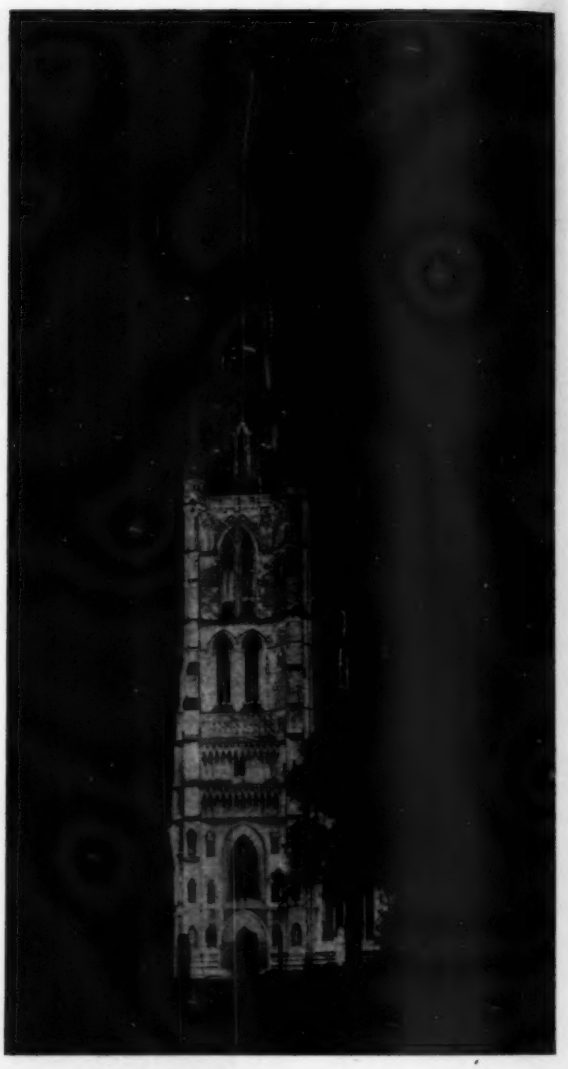
The beam of each of the above-mentioned projectors is substantially symmetrical about its main axis, but for applications where, for instance, one has to flood-light a long and high wall from a position very close to its

4 *St. Pancras' Church, London*

Flood-lighting of the interior of a colonnade to give a reversal of daylight conditions. The spilled light on some of the columns gives a gradation of light and shade sufficient to show that all of them are round.

5 *St. Matthias, Richmond*

Here the lighting has perhaps over-emphasized the horizontal features (mouldings of the window arches, parapet and string courses on the spire). The special lighting at parapet level for the spire may be considered too strong for local viewing but would be visible from a great distance.



6 *St. Wulfram, Grantham*

The eye ignores the fact that parts of the building near ground level are six times as bright as those near the top of the tower, which is a splendid example of 14th-century architecture, with a spire of height 282 ft. Compare the beautiful fade-away effect on the spire with that in Fig. 5.

foot the beam should be an asymmetric one, wide laterally to cover the lower parts of the wall, but more concentrated in the vertical plane so that the upper parts of the wall which are at a greater distance from the projector can be effectively illuminated. Mirrored trough-shaped reflectors with parabolic sections are normally used for this purpose, either g.l.s. or projector lamps being employed according to the degree of vertical concentration required. Sodium and horizontal-burning mercury-discharge lamps, which are virtually line sources of light, are also suitable for use with this type of projector.

The light distribution of any of the types mentioned may be modified by the nature of the front cover glass. If this is stippled, perhaps to avoid a streaky lighting effect, the beam will be widened in both planes; if ridged or made up of parallel lines of prisms the beam will be spread at right angles to the line of prisms but practically unchanged in the other plane. Internal or external louvres which are intended to prevent glare to bystanders may narrow the effective beam by reducing the light emitted at the extreme angles.

For prolonged satisfactory service it is essential for projectors to be robust and of good construction. They

have to operate out of doors in all kinds of weather, they may be used at a wide variety of angles of tilt and they are usually fitted with high-wattage lamps releasing a large amount of heat. If ventilated they must be weatherproof at normal angles of use, and the interior must be easily accessible for cleaning out the accumulation of dirt which inevitably gets drawn in as the fitting cools. If unventilated, the reflecting surfaces and lamp must not become overheated at any normal angle of operation. Flood-lights are very often mounted in awkward and relatively inaccessible positions, and it is advantageous if they are fitted with some kind of preset locking device which will enable them to be accurately re-trained even in daylight, after they have been disturbed for maintenance; some high-quality projectors have an additional optical device which enables the lamp to be reset at the correct focal position after cleaning or renewal, enabling a maintenance man to work day or night, with no hindrance from haze, or dazzle from other projectors.

Colour

Coloured lighting is attractive in itself but needs to be used with discretion or a bizarre effect may be produced. Taken singly, most stone and concrete buildings respond well to the yellow light of sodium lamps, red-brick structures to red neon light, and trees, foliage, etc., to the light of mercury lamps, but to appreciate colour, some contrast is necessary, and the effectiveness of a sodium-lit building, for instance, would be reduced by sodium street-lighting in front of it. The coloured lighting of parts of a building may be particularly effective on account of the contrast with other parts.

Under sodium flood-lighting everything yellow or white looks yellow, and all other colours turn grey; under neon lighting, reds and whites look red, and other colours are muddied or greyed. Thus, if either of these sources is used and it is desired to show white window sills as white, or window-boxes full of flowers in their true colours, it is necessary to provide white light locally, of sufficient strength to swamp the general lighting. With mercury flood-lighting, the same provision will be necessary for proper appreciation of red flags and flowers. Blue light tends to give a mysterious ghostly effect which can be well used in water scenes.

Strongly coloured light can be produced by the types of discharge lamps mentioned, by coloured fluorescent lamps, or by filament lamps behind colour screens. The last-named method may be preferred for short-term flood-lighting, or where a delicate selection of colour may be required, but since the colour effect is produced by extracting from the original white light all those colours which are not required, it is a wasteful process requiring considerably increased electrical load, and consequently is likely to be uneconomic in the long run. The approximate relative load required to give equal illumination of a building surface by various types of lamps of various colours is given in Table 1, although the figures are not strictly comparable owing to the different shades of colour produced by the alternative light sources in each colour group. The figure for white (uncorrected) light from filament lamps is taken as 100.

Table 1

Colour	Type of lamp	Relative load
White	Filament	100
	Fluorescent	40
Greenish-white	Mercury	60
Red	Filament	400
	Fluorescent	400
	Neon	200
Blue	Filament	1 250
	Fluorescent	125
	Mercury*	300
Green	Filament	400
	Fluorescent	30
	Mercury*	150
Yellow	Filament	200
	Fluorescent	50
	Sodium	30

* Special flood-lighting lamp.

Design Considerations

It is never possible to arrange for all the light contained in the beams from all projectors to strike the surface to be illuminated; some must always miss the outer edges. If a square surface, for instance, is to be lighted all over by one symmetrical projector directly in front of it, roughly one-third of all the beam flux will be spilled beyond its edges; in consequence, one has to provide 150% of the beam flux that at first sight appears necessary. This "waste light factor" will vary according to the shape of the surface to be illuminated and the number of projectors used. For a normal building lighted by eight or more projectors a factor of 1·2 will usually be sufficient, but for irregularly-shaped or small objects such as church spires or statues a factor of 1·5 or even more may be appropriate.

When light from the projectors strikes the surface it will have the effect of making it appear more or less bright, depending on the light flux arriving per square foot of surface and the ability of the latter to reflect the light. Furthermore, since the eye works more by comparison than by absolute values, a given brightness† will look brighter or darker if the surroundings are dark or bright respectively. Any design for flood-lighting must obviously correlate these factors, and although there will be occasions when some other overriding factors come into play it is a good general rule to estimate how much light is required, on the following lines.

Assume first that a perfectly white building in an isolated position would look sufficiently bright if it were to receive an illumination of 1 lumen/ft². This theoretical white building would reflect 100% of the light reaching it, but if it became dirty or weathered it might reflect only, say, 50%, when twice as much light would be required to give the same brightness.† Thus, an actual isolated

† Strictly, *luminance*. See B.S. 233: 1953, p. 5.

7 *Flood-lighting in miniature for the garden of a semi-detached house*

Two concealed 150-watt reflector spot-lamps, protected from the weather, can produce a delightful effect.

building would require (1 × the reciprocal of the reflection factor) lumens/ft². (The reflection factor of Portland stone varies from 60% to 20% depending on its cleanliness; that of concrete from 45% to 15%; that of dark stone from 30% to 10%; and that of red brick from 25% to 8%.) However, if the building is not isolated—if, for example, there are a few shops and street lighting to distract the eye—the illumination should be doubled; if the building is in a well-lighted central area it should be trebled, or perhaps increased even more, to give the same degree of prominence.

A simple example will make clear the method of planning a flood-lighting scheme of the type an electrical engineer who is not necessarily a flood-lighting specialist may be called upon to prepare. Suppose that it is desired to flood-light the face of the church shown in Fig. 8(*a*), which is in an isolated position and has a wide churchyard in which projectors can be placed. The surface is grey stone with an estimated reflection factor of 25%. The area of the face, excluding the roof, is 4 900 ft², and therefore the light flux required on the surface will be:

$$4\,900 \times \frac{100}{25} \times 1 = 19\,600 \text{ lumens}$$

It will be desirable for some light to strike the roof to show its shape, but spilled light will be sufficient and will be available if the projectors are more than 26 ft away from the wall. If they are placed on the ground, say 50 ft away, medium-beam projectors using g.l.s. lamps and having a beam spread of 50° (as given by the manufacturer) will each illuminate a roughly circular patch of wall about 47 ft in diameter. Three of these circles, slightly overlapping, will just cover the nave (to eaves) and the lower part of the tower, and a fourth (which is elliptical rather than circular owing to the angle of tilt) just covers the upper part of the tower. Thus four main projectors will be required, delivering a total flux of 19 600 lumens on the building surface.

Measurement or experience suggests a waste light factor of about 1·3, and the beam factor of this class of projector (as given by the manufacturer) will be, say, 0·45. Some allowance must be made for normal soiling of the front glass and some deterioration of the interior parts of the flood-lights for the same reason—how much one should allow depends on the type of reflector, the expected weather, and the probable frequency of cleaning; in this instance a figure of 1·5 is suggested.

Thus the total light flux required from the four lamps together is:

$$\frac{19\,600 \times 1{\cdot}3 \times 1{\cdot}5}{0{\cdot}45}$$

$$= 21\,230 \text{ lumens per lamp.}$$

A g.l.s. lamp of 1 000 watts (17 800 lumens) is the size of lamp that provides a flux nearest to the required value. To avoid a flat effect (Fig. 1) the four projectors might be placed as shown in Fig. 8(*b*), so that the light comes predominantly from slightly to the right, and the buttresses and other vertical features will cast shadows; these, however, will tend to be hard, and to soften them and also illuminate the left face of the tower a wide-angle flood-light with a 500-watt lamp might be placed at the left end of the line, trained as shown. The extra light from this would also partially compensate for the fact that the main lighting is produced by rather smaller lamps than are required by the calculation. The effect produced is shown in Fig. 8(*c*).

So far as the flood-lighting of buildings, etc., is concerned, there do not appear to be any major differences of technique between Great Britain and other countries. In the United States conditions probably favour long-range flood-lighting by narrow-angle projectors more than they do in Great Britain, and the French have

recently been very successful with their schemes using a few large units having 3kW lamps, compared with the normal British practice of using a greater number of fittings with lamps of consumption not larger than 1·5kW.

Mention must however be made of an outstanding French development, typified by the installation at the Palace of Versailles. This is not of lighting alone, but comprises both light and sound, magnificently staged and superbly executed. The general effect has been well described* by one of the writer's colleagues:

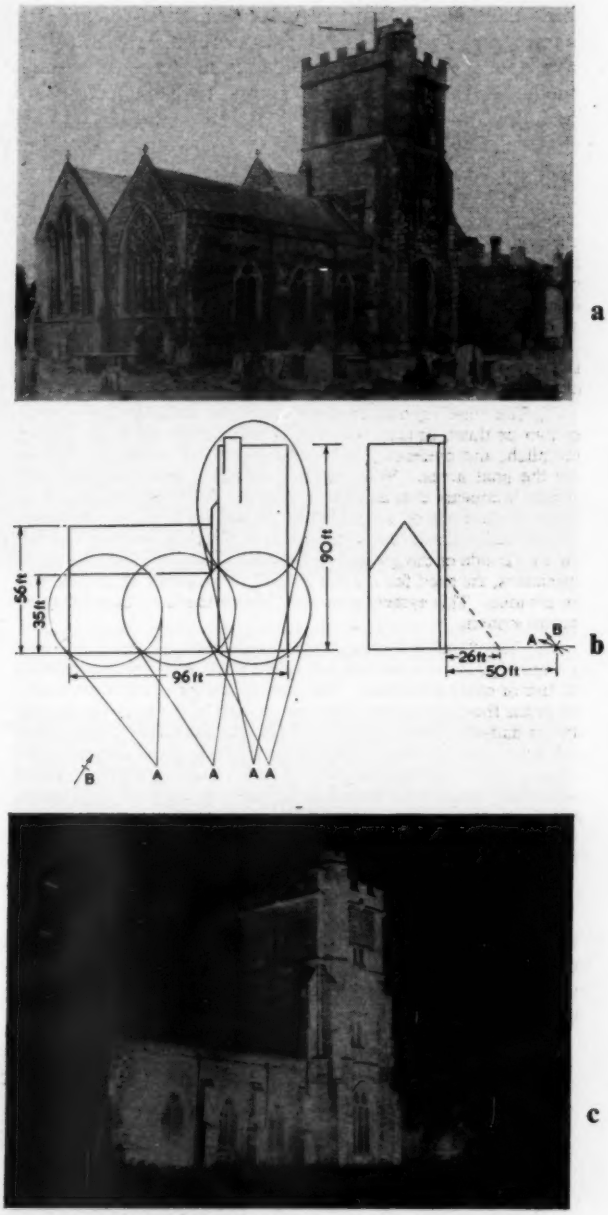
> At 9.45 it began.
>
> Suddenly, every light, every glimmer of light, vanished, and then, after just long enough for eyes and ears to reach the peak of expectancy, three tremendous chords broke the silence. And with each chord the entire building burst into light, faded to silent darkness, then burst into light again—the impact was overwhelming.
>
> Then followed the story of Versailles:
>
> You heard how it began as a *maison de chasse* of Louis XIII, and the lighting picked out the original building. You saw how it expanded and how the gardens were planned. Louis XIV entered, *le roi soleil*, his footsteps echoing in the distance, his ushers announcing him.
>
> "*Messieurs, le Roi!*" sounded faintly down the corridors. The footsteps approached—"*Messieurs, le Roi!*"—the music swelled, the steps grew louder, and all the time the lighting followed his progress through the palace.
>
> It was as though the very building were speaking and it was the same when it came to the revolution. . . . There were lights in the rooms where the queen and royal children prepared for flight. You almost saw them as the lighting, fierce, then dimmed like a passing gust of wind, whirled their frightened voices and the sound of the coaches away into the night.

Have we, in Great Britain, no history, no buildings, which could be brought to life in this way? And if the French can make it pay, could not we?

Flood-lighting for Football

In the application of flood-lighting to football, unlike the ones previously referred to, science is much more important than art, and the installation must always be able to show a profit. It is mainly the spectators that one has to cater for, because many of them are at some distance from the point of play, and if they can see well enough it can be taken for granted that the players can see well enough too, provided that they are used to the conditions. But it is understandable that a team used to a high standard of lighting might justly complain if expected to play on some rival pitch with inadequate lighting, and it is therefore to be hoped that the Football Association and the Amateur Football Association will insist on certain minimum standards to ensure reasonably uniform lighting conditions for the grounds used by clubs likely to be opposed to each other.

Provided that glare does not become excessive, the more light there is, the better visibility will be, but glare, which causes discomfort and visual disability, increases with the intensity of light projected in the direction of the viewer, and with the nearness of the source of light to the normal line of sight. To give adequate lighting, low-intensity projectors must be located fairly near the part of the pitch they serve, but projectors sited as far as possible from normal lines of sight have to be of high-intensity to be effective. Thus there are disadvantages in both types of projector, but one has to choose one or



8 *Fordingbridge Church*
(*a*) View by day.
(*b*) Arrangement of projectors:
A. 1 000-watt for main lighting.
B. 500-watt for relief effects, from the opposite angle.
(*c*) The flood-lighted building at night.

* Freeth, T. O.: "Le Château qui Parle," *Lighting Service*, 1954, 3, No. 4, p. 3.

the other, or a compromise between the two, and the choice is very often dictated more by the facilities available than by other considerations. The three main methods which experience shows to be effective are as follows:

(i) The "four-corner" system, in which groups of projectors are mounted on high towers located on or near the extensions of the diagonals across the pitch. The minimum angle of elevation from the centre of the pitch to the lowest projector should be 20° (i.e. a mounting height of 90ft at a distance of 250ft), and generally all parts of the field are lit by projectors in each group. This system has the merit of there being only two groups of projectors in view at any one time, and glare is received by a player or spectator only from those individual projectors which are trained in his direction. In some cases, however, the roofs of stands would cause too much obstruction of the light to permit this system to be used.

(ii) The "line" system consisting of single flood-lights, or groups of two or three, spaced on poles or stand roofs on either side of the pitch, and preferably with some additional downward lighting for the goal areas. With specially designed low-brightness projectors it appears that acceptable lighting can be obtained with an angle of elevation of about 15° to the nearest point on the longitudinal centre-line of the pitch, but as at least one of the projectors on the far side of the ground will always be near the line of sight of spectators, the need for careful control of projector brightness will be obvious. This system gives less "player shadow" than the four-corner system.

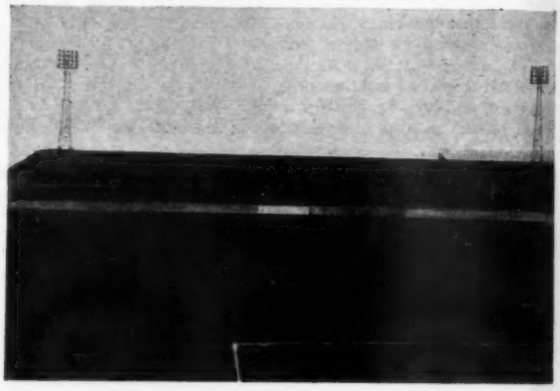
(iii) The "multiple-group" system consists of three or more groups of projectors on each side of the pitch, each group consisting of four or more projectors. The minimum angle of elevation to any projector from the centre of the nearer half of the pitch (as divided by the half-way line) should be 15° or 20° according to the type of projector used, the latter figure applying to the more concentrating types. With this system the location of the groups is largely dependent on possible obstruction caused by the front edge of the stand roofs, and their number must be such that, in relation to their location and height, they give reasonably even lighting along the touch-lines.

It is reasonable to relate the installed lighting load to the ground capacity, since with large crowds the spectators near the back will be a considerable distance from the players and will need more light, in order to be able to see the play clearly, than would be required for a spectator nearer the touch-line. The recommended relationship is given in Table 2.

Table 2

Ground capacity	Minimum power	Recommended power
	kW	kW
Up to 20 000	40	40–60
20 000 to 40 000	60	60–100
Over 40 000	80	—

The above figures refer to the total nominal wattage of the lamps installed, but a good case can be made for deliberately overrunning the lamps by some 10% (e.g. using 220-volt lamps on a 240-volt supply). The average life of the lamps will be reduced to about one-third of



9 *Leeds United football ground*

Two of the towers for this "four-corner" flood-lighting installation each carry 20 projectors at a height of about 75ft above the pitch. The total load is 91kW. In such situations mechanical locking devices which enable the projectors to be returned to their pre-selected training angle after cleaning are especially valuable.

10 *Crystal Palace football ground*

A "multiple-group" system of 8 groups, each of ten 1 000-watt projectors, at a height of approximately 65ft. The lamps are overrun by 10% excess voltage to give considerably increased light output, combined with a life adequate for this application.

11 *Watford football ground*

An example of the "line" system, in which groups of two or three 1 500-watt flood-lights are mounted at a height of approximately 36ft. The fittings have low-brightness satin-finished reflectors, and a cap in front of the lamp to prevent direct view of it. The total load is 78kW.

normal but their light output will be increased by over one-third. Thus the effectiveness of an installation planned to comply with the lower limit of the recommendations when the lamps are used in the normal manner can be increased to approach that obtained from the upper limit, with no increase in capital cost, but owing to the extra heat from the overrun lamps it will be more than ever necessary to ensure that only projectors of the highest quality are used.

Amateur-club grounds with a capacity over 5 000 should have an installation comparable with that for professional clubs, but for smaller clubs and for recreational pitches both the installed load and the mounting height can be considerably reduced in the interests of economy. Most of the clubs concerned have a very small income, and some light is better than none at all.

This sentiment is of course the main reason that the recommended lighting for all classes of football is so modest. Schemes complying with the recommendations above are easily within the economic reach of the clubs concerned; in at least one case the whole cost has been more than paid off by profits from flood-lighting in less than two years. But flood-lighting is still regarded as something of a novelty; when it is taken more as a matter of course, then perhaps will be the time to consider whether this national sport does not deserve lighting conditions better than what we at present call "adequate" and what others would certainly call inadequate by their standards. For instance, at Caracas, Venezuela, for a ground capacity of only 35 000 the installation comprises 432 flood-light projectors with a total load of 745kW—about 10 times as much as is being used for a comparable ground in Great Britain, but not unusually large in the New World.

It is sometimes assumed that flood-lit football would be impossible in conditions of mist or light fog, but in fact visibility under flood-lights at night is no worse, and may even be better, than under similar weather conditions in daylight.

12 *Caracas, Venezuela*

Three of the six batteries, each of 72 1 500-watt projectors, mounted 147ft high. The lamps are overrun by 10% excess voltage as are those in Fig. 11.

New Zealand

Australia

Canada

1 Huka Falls, Waikato River, New Zealand

A Few Impressions from a Three-Month Tour by E. T. Norris, Member

THE tour of which I am writing took place from July to October, 1954, and embraced the North and South Islands of New Zealand; all the capital cities of Australia, including Hobart, Tasmania; and British Columbia, Winnipeg, Ontario and Montreal, in Canada. The business side of the tour was concerned with transformers in particular and thus it covered many matters relating to transmission and distribution in general.

I propose to describe briefly some impressions of technical and domestic conditions and practices which differ significantly from those in Britain.

In New Zealand, the organization of electricity supply is much on the same lines as in Britain with a central authority and regional boards—it would give a correct chronological emphasis to reverse the comparison. Much attention is paid to power factor so that overall values from the individual loads through to the generators usually exceed 0·95, and these are attained either by capacitor compensation or by synchronous condensers. Lightning arresters are in general use, but neither earth wires nor protective rod gaps are fitted. Fault performance seems to be as good as in Britain, where the opposite practice is more usual. Neutrals are solidly earthed. Considerable attention is given to balancing the load: static balancers are not used, but normally at least two phases are taken into every house with the water heater as a separate—time-controlled—service.

The load factor is generally high and may reach 75–80% owing to water heating, dairies and freezing plants, since the load due to freezing plants is seasonal. Since generation is almost entirely from water power the bulk-supply tariff consists of a demand charge only. It is likely, however, that an energy charge may be introduced in the near future.

The supply to any sparsely populated area which would be uneconomic to the regional power board is financed by grants from a central fund, to which every regional board contributes a fraction of 1% of its gross revenue. The fund is administered by a representative central committee. This method seems to be regarded generally as highly satisfactory.

The possibility of generation from the geothermal regions around Wairakei are of unusual interest. There are at present about a dozen experimental boreholes discharging continuously to the atmosphere. These create noise and cloud effects which are quite impressive, but neither of course will be present when power is generated.

In Australia, owing to the wide spacing of industrial centres, there cannot be the same co-ordination of supply, and practice is more diverse. In the 132kV networks both solid earthing and arc suppressors are used.

In both New Zealand and Australia planning for load growth is realistic, and large new stations are under construction. Owing to comparative limitation of both finance and labour, the scale of operation, particularly for hydro-electric stations, contrasts with American and Canadian practice. There, the impression is of rows of bulldozers, streams of excavators, and long lines of heavy trucks bringing and taking away material and working continuously round the clock—a canteen serving simultaneously breakfast, lunch and dinner every 25 minutes of the 24 hours, with a notice on the canteen door: "Please queue up four abreast." The times required for the construction of power stations may be judged from this picture. Economic comparison is not so obvious.

Following a universal trend, most of the supply authorities in New Zealand and Australia have been grouped into national or statutory bodies, and these operate on a comparatively large scale. Their engineers and executives are for the most part conscious of the political implications of the constitution of these bodies, and consequently tend to circumscribe their responsibility to purely engineering considerations. It is generally assumed, for example, that any price preference for the British manufacturer is entirely the responsibility of the

Government and is so prescribed by them in the national preferential duty, if any.

Since a previous visit to these countries which I made in 1949, when delivery was the overriding consideration for all heavy engineering plants, price competition has become world-wide and is now a dominating factor. This, combined with the present-day view just described, tends to explain the experience that, of the many large orders for heavy electrical engineering plant encountered during the visit, none was placed with a British manufacturer. It is perhaps pertinent to cite here a statement made some years ago* that when a customer becomes large enough to be of vital importance to the individual manufacturer, a competent purchasing department can buy below cost if there are two or more tenderers in open competition.

On the domestic side, an outstanding feature of travel in these three countries is cleanliness. The few heavy industries are in general isolated and there is little coal burning. Since practically all houses are of wood and seem always to be freshly painted in various colours, the towns look very bright and cheerful. The cleanliness and brightness extend to theatres and cinemas, since no smoking or drinking is allowed.

In Australia and New Zealand the normal working week is five days, 40 hours. Workers get two weeks' leave and nine days of statutory holidays with pay, in addition to seven days' sick pay each year. The latter is cumulative and can be taken at any time regardless of health. There is practically no domestic help and charwomen get 4s. to 6s. an hour. Meetings, except with senior engineers, can be depended upon to close promptly at 5 p.m.—the public houses shut at 6 p.m.† Licensing hours in hotels and restaurants vary widely and seem to differ for every town one visits.

In New Zealand taxation laws are more rigid in detail than they are in Britain. Death duties are more rigorous and all gifts above £200 per annum are taxed, irrespective of time. The public must obtain their own income tax forms from the Post Office and send them in themselves. As an example of the comprehensiveness just referred to, one clause on this form states that "profits from an illegal business are assessable and must be returned for taxation purposes in the same way as profits from any other business."

In New Zealand, as might be expected, butter is the same price as margarine in Britain, and the housewife can buy half a sheep for 25s.

2 *Steam from a geothermal bore at Wairakei, New Zealand*

To me and my wife, outstanding attractions in both countries are oysters and wine. Oysters can be bought at 1s. 6d. per dozen in the shops and are seldom more than 3s. per dozen in a first-class restaurant. I can testify that four dozen at one sitting are not impossible. The best Australian wines are comparatively cheap and bear no relation to the varieties marketed in Britain.

A striking illustration of the changing conditions in Britain during the last five years is that in my 1949 visit we eagerly brought home the legal allowance of 50lb of food-stuffs each. On this visit nothing excited such interest, but the luxury of red sockeye salmon from British Columbia.

These impressions have no official significance and are not claimed to be authoritative; they are, however, sincere.

* *Cf. Journal I.E.E.*, 1946, 93, Part I, p. 39.
† Since my visit the law in New South Wales has been changed.

3 *Substation at Kitimat, British Columbia*

Journal I.E.E., April 1955

ACROSS THE PENNINES

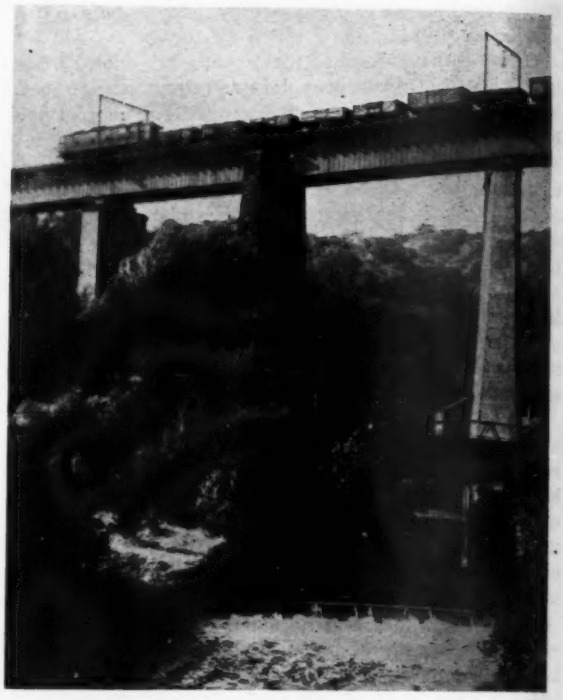
Electrification of the Manchester–Sheffield–Wath Lines

An article on some aspects of the electrification of the Manchester–Sheffield–Wath line, which is the first main line in Great Britain to be fully electrified. The completion of this work took place in January, and the electrification is of particular importance in view of the British Transport Commission report on railway modernization, which has now been approved. Technical details of the scheme are given in a paper by Mr. J. A. Broughall and Mr. K. J. Cook, which was read before The Institution on the 2nd December, 1954, and is republished in this month's issue of the Proceedings.

"MOUNTAINS we go round; hills we go over or through." Thus the long-established maxim of the railway engineer. But when a natural obstacle of the magnitude of the Pennine Chain becomes classed as "hills," even the most sanguine engineer pauses for wry consideration.

Yet, in truth, he had no alternative but to lay his metals across this barrier, for the link between the prosperities of Lancashire and Yorkshire became more essential as the industrial 19th century gathered momentum. So the rails wound upward, east from Manchester and west from Sheffield; but for some years the very summit balked the engineers, and passengers had to leave their trains at Woodhead or Dunford Bridge and travel the 3¼ miles between these points by coach. Little could irk the railwayman more or spur him to greater effort to drive a tunnel through the rock 950ft above sea level, that the link might be complete. So hazardous a venture was this that even the redoubtable George Stephenson had no faith in it. Yet the bore was made, and on the 22nd December, 1845, the first Woodhead tunnel was formally opened, just over three miles long and carrying but a single track. This was false economy, for within seven years the traffic had grown to such proportions that a second tunnel had to be driven.

During the next hundred years the growth of traffic on the line mirrored the development of the Industrial North. In the west the textile city of Manchester began sprawling outward, growing in size and wealth as the world-wide demand for its industrial produce increased. Around it too, grew the other great manufacturing towns of Lancashire; mills, foundries, factories, all stabbed their chimneys skyward by the hundred, as steam came to power the engines and mechanization got into its stride. And every belching smoke-stack meant coal; more coal than Lancashire could supply. But Yorkshire could. Pit after pit poured forth its black treasure, and



1 *Broadbottom viaduct, Mottram*

In the days of smoke and steam the water seldom sparkled in the sunlight and the foliage of the trees was dirty.

the skeins of laden wagons grinding slowly into the hills grew longer, heavier and more numerous as the mineral stream swelled. The railway had come into its own.

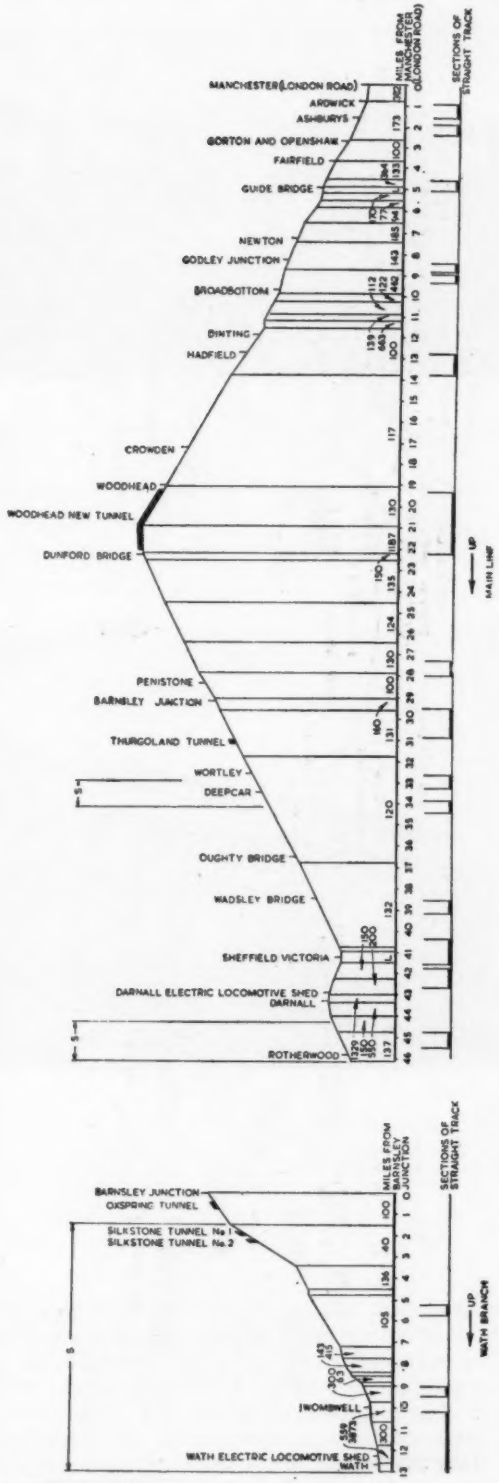
This growing demand for minerals patterned the development of the traffic as control of the line passed into the hands of the Great Central Railway Company and later of the London and North Eastern Railway Company; by the beginning of the present decade there were about 80 freight trains running west to the marshalling yards at Mottram, Godley and Guide Bridge each day, with only 60 in the opposite direction—mostly empty wagons returning to the yard at Wath. By contrast, there were only 14 passenger trains in each direction between Manchester and Sheffield, and none on the Wath branch. This volume of freight traffic, unusual both because of its density and its high proportion of the total, produced operating problems of no mean complexity, while the tortuous, steeply graded nature of the track (Fig. 2) added greatly to the difficulties. So did the fact that almost all the freight trains needed two locomotives, thus doubling the number of machines and crews necessary. And on the notorious Wentworth Bank, where the ruling gradient is 1 in 40 for 2·2 miles, two more locomotives had to be provided to assist the 1 100-ton trains upwards at 5m.p.h. At the top of the Wentworth Bank the bankers were taken off; and because

the trains comprised loose-coupled wagons, not fitted with continuous brakes, a check was made at the summit, at Dunford Bridge, to pin down manually the brakes on a proportion of the wagons before the steep down grades were tackled. And the check was also useful in enabling the locomotives to "get their breath back," for the long up-haul demanded all the steam they could give. It was a long enough trip under the best of conditions, but when the icy northern fogs came down from the moors and thickened with the sulphurous fumes from the trains, the journey became a nightmare for the crews. Then on to the Woodhead tunnel and three blinding miles of pitch-black acrid smoke, which seemed unable to escape from the underground bore. Indeed, so bad were the conditions that smoke was still coming from the vent shafts of the old tunnel some two months after it had been abandoned.

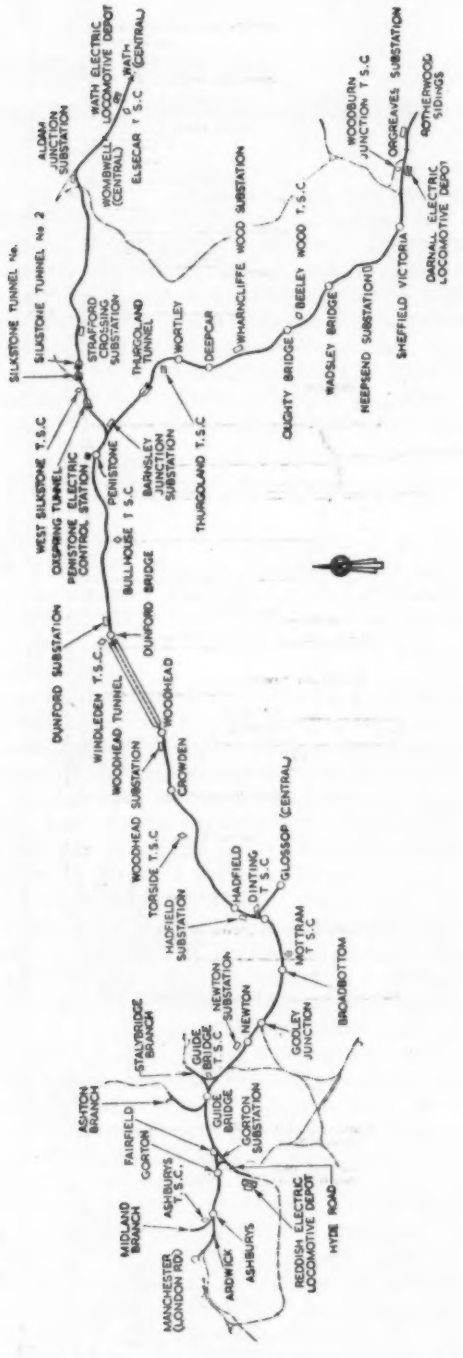
Small wonder, then, that the line was considered for electrification many years ago. This measure was advocated in a report to the L.N.E.R. Board in 1926, but the gathering clouds of economic depression prevented realization of the idea. In 1936, however, the L.N.E.R. Board authorized electrification, and Government assistance was given under a scheme to relieve unemployment. But it was a long journey from authorization to implementation, and an organization had to be created to carry out the work. Slowly the spade-work went ahead. The decision was taken to use a 1 500-volt d.c. overhead system with regenerative braking on the locomotives, to retain the old tunnels and semaphore signalling and steam shunting locomotives. Then it was found that the existing route plans were inadequate, and an aerial survey had to be made. Already postponed ten years by the depression, the scheme experienced the first of the many setbacks which it was to suffer.

Over all hung the dreaded word "subsidence": from Wath to the very top of the Wentworth Bank the whole line was subject to it, as the earth sank to fill the great honeycomb of subterranean caverns from which men had hewn millions of tons of coal. Every structure had to be designed to allow for the track level changing by several feet. At Wath itself, even the locomotive shed and turntable have been built to allow for it. The shed is a marvel of engineering, for it is articulated in four sections, with even the power cables carried in conduits with flexible joints; this was no mere pessimism, for the shed subsided by about two feet in the first four years of its life. Despite these difficulties, however, the organization came into being and commenced operation, locomotives were designed, contracts were placed and work was begun on the provision of foundations and the erection of gantries. The routes are shown in Fig. 3.

Then came the war, and the complete cessation of all work for six years. The teams which had so painstakingly been gathered together were dispersed, so that when recommencement was authorized in 1946, the engineers had virtually to begin again. Much had changed. In 1944 the scheme had been modified to take account of the conditions expected to prevail in



2 *Gradient profiles*
S.—Areas subject to mining subsidence.



3 *Electrified lines*

——— Manchester–Sheffield–Wath electrified lines.
– – – – Other lines.
T.S.C.—Track-sectioning cabin.

Substation and track-sectioning-cabin mileages (Fig. 3)

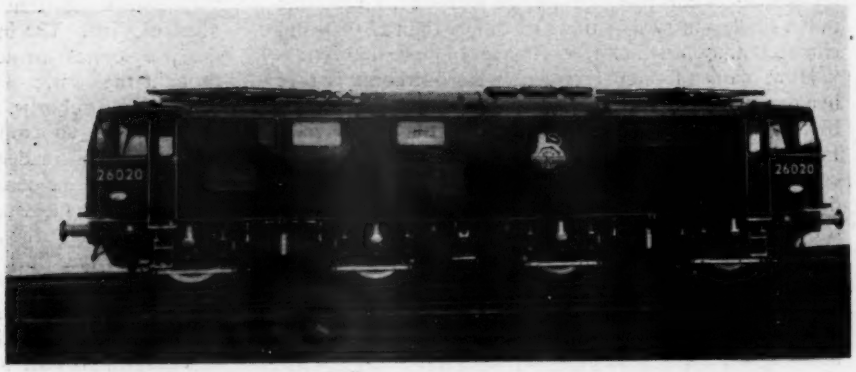
From	To	Miles
Main Line		
London Road station	Ashburys T.S.C.	1·57
Ashburys T.S.C.	Gorton substation	1·59
Gorton substation	Guide Bridge T.S.C.	2·46
Guide Bridge T.S.C.	Newton substation	1·79
Newton substation	Mottram T.S.C.	3·49
Mottram T.S.C.	Hadfield substation	1·97
Hadfield substation	Torside T.S.C.	2·70
Torside T.S.C.	Woodhead substation	3·82
Woodhead substation	Windleden T.S.C.	3·15
Windleden T.S.C.	Dunford substation	0·96
Dunford substation	Bullhouse T.S.C.	2·56
Bullhouse T.S.C.	Barnsley Junction substation	3·44
Barnsley Junction substation	Thurgoland T.S.C.	2·81
Thurgoland T.S.C.	Wharncliffe Wood substation	2·59
Wharncliffe Wood substation	Beeley Wood T.S.C.	2·42
Beeley Wood T.S.C.	Neepsend substation	2·99
Neepsend substation	Woodburn Junction T.S.C.	2·73
Woodburn Junction T.S.C.	Orgreaves substation	2·35
Orgreaves substation	Rotherwood (end of wiring)	1·04
Wath Branch		
Barnsley Junction substation	West Silkstone T.S.C.	1·40
West Silkstone T.S.C.	Strafford Crossing substation	2·65
Strafford Crossing substation	Aldam Junction substation	4·69
Aldam Junction substation	Elsecar T.S.C.	2·13
Elsecar T.S.C.	Wath	1·49
Glossop Branch		
Dinting T.S.C.	Hadfield substation (main line)	0·64
Dinting T.S.C.	Glossop	0·99

the post-war economy. Estimates of its cost had more than doubled, and were then £6 000 000, and the need to avoid the contentious lodging turns for locomotive crews was anticipated; this meant faster, and so lighter, trains, which in turn involved resiting signals to give longer stopping distances. So the old 1 100-ton trains with up to four locomotives were to give place to 750-ton trains with but one electric engine between Rotherwood and Dunford, and 850-ton trains with two locomotives (the banker at the tail) between Wath and Dunford; both loads were to be worked thence to Manchester by a single locomotive.

Plans were laid for a resumption of work in 1946, but on Government orders the Liverpool Street–Shenfield electrification was given priority. Then came the next blow, which might have killed the scheme. Efforts to maintain the Woodhead tunnels failed to cope with the increasing decay wrought by a century of steam working and the constant seepage of water from the acid shale through which the bores were driven. It needs little imagination to visualize the effect upon the overall cost and working time-table of the driving of a new tunnel more than three miles long.

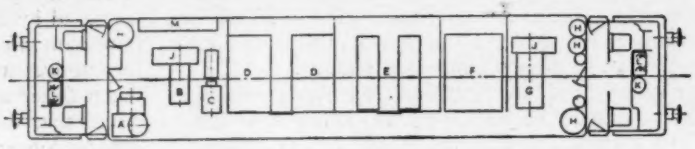
So to nationalization, and further alterations while control of the railways was passed into the hands of the Railway Executive under the British Transport Commission. Electrification and other schemes for modernizing transport now became affairs of State, and were reviewed on a national basis by new committees in the light of post-war inflation. Once more the scheme was modified. The electrification of the lines from Reddish to Manchester Central and Trafford Park was postponed indefinitely, the accommodation at Reddish Depot was reduced and only 65 locomotives were to be provided. Despite this, the estimated cost had risen to nearly £11 000 000.

When the engineers finally returned to full-scale



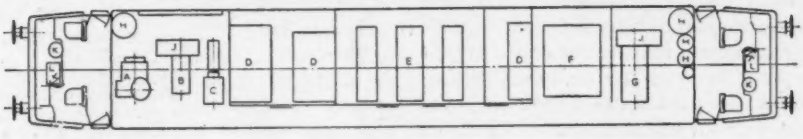
4 $B_0 + B_0$ *locomotive—layout of equipment in body*

A—Compressor.
B—Supply motor-generator.
C—Exhauster.
D—Resistors.
E—High-voltage compartment.
F—Boiler.
G—Exciter motor-generator.
H—Air reservoirs.
J—Traction-motor blowers.
K—Hand brake.
L—Master controller.
M—Battery.



5 $C_0 - C_0$ *locomotive—layout of equipment in body*

A—Compressor.
B—Supply motor-generator.
C—Exhauster.
D—Resistors.
E—High-voltage compartment.
F—Boiler.
G—Exciter motor-generator.
H—Air reservoirs.
J—Traction-motor blowers.
K—Handbrake.
L—Master controller.



working on the line the situation was far from encouraging. On the credit side were more than half a year's work on the new tunnel, about 100 single-track miles of line provided with gantries and one working locomotive—on loan to the Netherlands Railways. The debit side of the picture was indeed grim. The scheme was already 13 years old and the North had lost faith in it; the great demand for transport precluded free working access to the line during the normal industrial week, so that much of the line work would have to be done during the week-end—always a costly procedure. Only by careful planning could the Motive Power Department release engine drivers for their 5-week training course as motormen. The overhead steelwork already erected required careful examination and maintenance, and there was much more erection to be done, largely in the most difficult places—the marshalling yards. And the subsidence had got worse; some little indication of the

seriousness of this problem may be gleaned from the fact that a single gantry sometimes cost more than £2 000, and can accommodate track-level changes of more than 5ft.

How many of these problems were overcome is told in a paper* read before The Institution on the 2nd December, 1954, and published this month in the *Proceedings*. Faith was regained as the work proceeded, despite bitter conditions on the line during the bad winters of this decade, conditions so bad that merely being on the line for an 8-hour shift was exhausting. The pre-war $B_0 + B_0$ locomotive came back from Holland after running successfully for more than 330 000 miles, and 57 more were constructed at the Region's works at Gorton, as were the seven newly-designed C_0–C_0 locomotives with top speeds of 90m.p.h. Figs. 4 and 5 show the appearance and layout of these engines and Table 1 compares their salient characteristics. The first locomotive ran at Wath on the 3rd June, 1951, and from that time on the rate of progress improved steadily.

The engineers had taken in hand the worst section first, for the 18 miles between Wath and Dunford Bridge provided a multiplicity of testing points; it thus became the first piece of concentrated freight haulage by electric traction in the British Isles, and provided much valuable experience for future electrification. By August, 1953, the new Woodhead tunnel was completed, despite a 72ft collapse at the Woodhead end during 1952. All along the track many old bridges had been raised to give clearance for the pantographs, which in turn meant building up the embankments carrying the roads to the bridges. On the Wath line this is a never-ending task, for the ceaseless subsidence reduces clearances and cracks bridges without warning. In spite of these difficulties, all freight traffic between Wath and Dunford Bridge has been hauled electrically since February, 1952, and all trains from Penistone to Manchester (London Road) since the 14th June, 1954; the last steam locomotive went through the old Woodhead tunnel at midnight on the 12th June, 1954—to the great relief of all the crews—and the full electric passenger service was operating in September, 1954. Freight working between Rotherwood and Barnsley Junction was brought in on the 3rd January, 1955, and the job was complete. Faith and enthusiasm finally triumphed over every setback; it had been a long-drawn battle fought over nearly 20 years, but in judgment it must be remembered that only about 10% or so of the work was completed before the end of 1949, and it was not until then that work really started. So it may without undue distortion be claimed that some 300 single-track miles of the most difficult line in Britain have been electrified in five working years, without free weekday access and under a surfeit of appalling conditions—an achievement which compares favourably with pre-war schemes and augurs well for the future.

Ancillary to the main line conversion has been the provision of a fast suburban service between Manchester, Hadfield and Glossop, using 3-car multiple-unit stock very similar to that used on the Liverpool Street–Shenfield line. The impact of this service on the life of the people has already been considerable, for it has brought the centre of Manchester within easy reach of the scattered suburbs. Nowhere is its effect more clearly seen than at Glossop, whose people have been complaining of the inadequacy of their railway service for 60 years; once a decaying town, its future now seems bright, and the Glossopian enthusiasm for the electrification is shown by the great increase in passenger traffic which occurred during the first three months of its operation.

Yet this impact is also felt on the main line, where the service between Manchester and Sheffield has not been so vastly improved; in the first few months of electric service the passenger traffic between these points has increased by 35% and is still increasing. But the most important effect is on the freight service, for the electric locomotives are moving the minerals over the hills so much faster and more reliably than was possible with steam that the marshalling yards at the receiving end can no longer clear them rapidly enough, and further electrification is becoming desirable to keep the freights moving. Some idea of the improvements in service can be gained from Table 2; the most noticeable changes are in the booked times of the freighters, but these do not tell the full story, for electrification has made it possible to bring the actual journey times to within minutes of the booked times—a rare occurrence in the days of steam.

Indeed, although the full scheme is in its infancy, the changes it has wrought have been vast. The moorland air has a clarity it has lacked for nearly a century; flowers now bloom in the valleys where once only the smoke lay; and the birds have come back to haunts from which the fumes drove them so long ago. The new life and brightness of the countryside are fast outweighing any "loss of amenity" caused by the presence of the overhead structures. Courage and skill have made

Table 1. Leading Particulars of Locomotives

Data	$B_0 + B_0$	C_0–C_0
Length over buffers	50ft 4in	59ft 0in
Wheel base	35ft 0in	46ft 2in
Wheel base of bogie	11ft 6in	15ft 8in
Distance between bogie centres	23ft 6in	30ft 6in
Overall width	9ft 0in	8ft 10in
Maximum height of body	13ft 0in	13ft 0in
Maximum height over raised pantographs	21ft 0in	21ft 0in
Weight in working order	86 tons 14cwt	102 tons 10cwt
Tractive effort—starting	45 000lb	45 000lb
Tractive effort—full-field continuous rating	14 600lb at 32m.p.h.	20 100lb at 44m.p.h.
Maximum speed	65m.p.h.	90m.p.h.
No. of motors	4	6
One-hour rating—full field	435h.p.	450h.p.
One-hour rating—weak field	467h.p.	460h.p.
Total locomotive 1 hour horsepower (weak field)	1 868	2 760
Motor ventilation	2 000ft³/min	2 200ft³/min

* Broughall, J. A., and Cook, K. J.: "The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways," *Proceedings I.E.E.*, Paper No. 1744, November, 1954 (102 A, p. 159).

6 *Woodhead portal, with the new station buildings, signal box and substation; part of the old entrance to the tunnel can just be seen to the left of the new portal.*

possible a great step forward; to ride an 850-ton train smoothly up the Wentworth Bank at 12m.p.h. driven partly by power fed into the line from the regenerating locomotives passing down, and to breathe the crisp winter air throughout the sparkling cleanliness of the Woodhead tunnel, are highlights which point to present achievements. And to talk to the men of the line is to realize that their enthusiasm does not blind them to the lessons they have learned and the need for still further improvements. They have learned how to run trains cleanly and effortlessly; and they foresee the coming of regular-interval freight services with the precision of the best passenger lines. Successfully they have electrified one of the worst lines in the country, in face of heart-breaking setbacks and difficulties; they are experienced, and face the future confidently; all they want is the signal to carry their catenaries onward, the green light signal for progress—"clear road ahead."

Table 2. Comparative Train Timings

Class of train	From	To	Steam	Electric
			min	min
Down Trains				
Express passenger	Sheffield (Victoria)	Manchester (London Road)	70	56
Multiple-unit	Glossop	Manchester (London Road)	37	32
Express freight	Sheffield (Bridgehouses)	Manchester (Ducie Street)	86	69
Mineral	Woodburn Junction (Pass)	Mottram Yard	138	81
Mineral	Wath Yard	Mottram Yard	162	97
Up Trains				
Express passenger	Manchester (London Road)	Sheffield (Victoria)	68	56
Multiple-unit	Manchester (London Road)	Glossop	39	34
Express freight	Ardwick (East)	Sheffield (Bridgehouses)	87	69
Goods	Ashburys West	Woodburn Junction (Pass)	154	101
Empties	Dewsnap Yard	Wath Yard	177	86

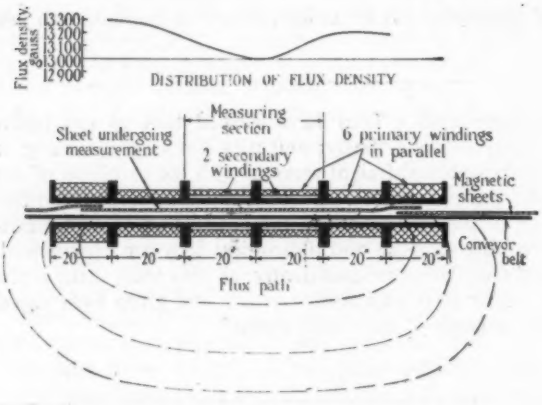
Note:—The electric service between Manchester (London Road), Hadfield and Glossop is a ½-hour interval service between 5.15a.m. and 7.45p.m., and then hourly to 10.45p.m.; trains are increased from 3 to 6 coaches during the rush periods.

Factory Measurements

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1703) ENTITLED "ELECTRICAL AND MAGNETIC MEASUREMENTS IN AN ELECTRICAL ENGINEERING FACTORY," BY D. EDMUNDSON, B.SC.(ENG.), MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN SEPTEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

VAST AND HETEROGENEOUS though the subject of factory measurements is, it is possible to trace the effect of a few simple techniques in shifting the emphasis in instrumentation from the instrument-maker's skill to that of the circuit designer. Two components, the radio valve and the high-speed relay, underlie all the changes which are worth recording. The variety of the measurements described is characteristic equally of the versatility required of the measurement engineer and of his tools.

A typical example is the whole-sheet tester, which measures the specific loss in sheets of silicon iron as they move on a conveyor belt through a large coil at the rate of ten a minute. Fig. 1 shows the general shape of the

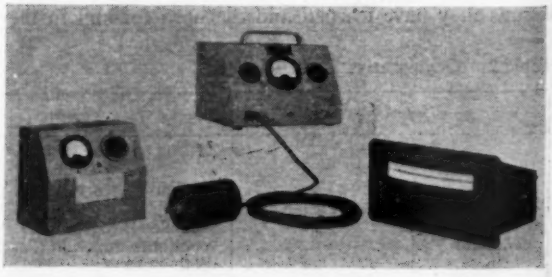


1 *Whole-sheet tester*

apparatus. The measurements do not differ in principle from traditional laboratory methods, but they are rendered almost completely automatic by the use of amplifiers in adjusting the flux density and in supplying the wattmeter. But the amplifier-wattmeter is something of more general significance: the same circuit can provide not only greater convenience, but enhanced accuracy in testing small motors under factory conditions. A number of the instruments shown in Fig. 2 are amplifier-supplied.

2 *Amplifier instruments testing small motors*

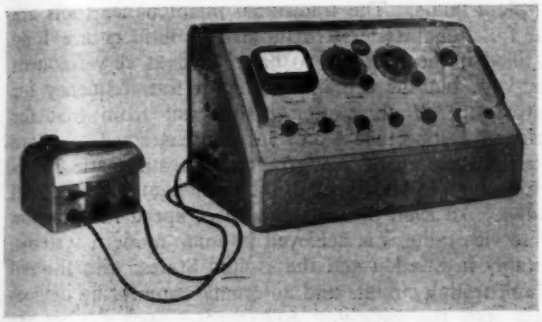
The use of the high-speed relay, with or without amplifiers, can solve the most diverse problems. One complete group is based on Maxwell's commutator bridge.



3 *Frequency- and speed-measuring instruntents*
Left to right: mains-frequency meter; slip meter; tachometer.

Fig. 3 illustrates a precision tachometer, a mains-frequency meter and an instrument for measuring induction-motor slip, all using the simple condenser-

charging system developed by Maxwell to measure the ratio of the electromagnetic and the electrostatic units of charge. But whereas the first two are based exclusively on the high-speed Carpenter relay, the slip meter depends also on a high-gain selective amplifier to drive the relay coil from the minute slip-frequency field which surrounds induction motors.



4 *Dynamic hysteresis tester*

The introduction of an amplifier drive for a high-speed relay opens up the possibility of its use as a precision device, for "dwell" times can be accurately controlled. Thus, a power-factor tester for insulating materials depends on the phase relation between the contact time and the current passing through the specimen. A very similar application uses the same technique as a replacement for the traditional commutator for magnetic measurements. In this way dynamic hysteresis loops can be readily measured with the apparatus illustrated in Fig. 4. Or, for the more traditional measurements, amplifiers can be used to drive conventional instruments, and can enable permeability measurements to be carried out as a mere by-product of routine loss testing.

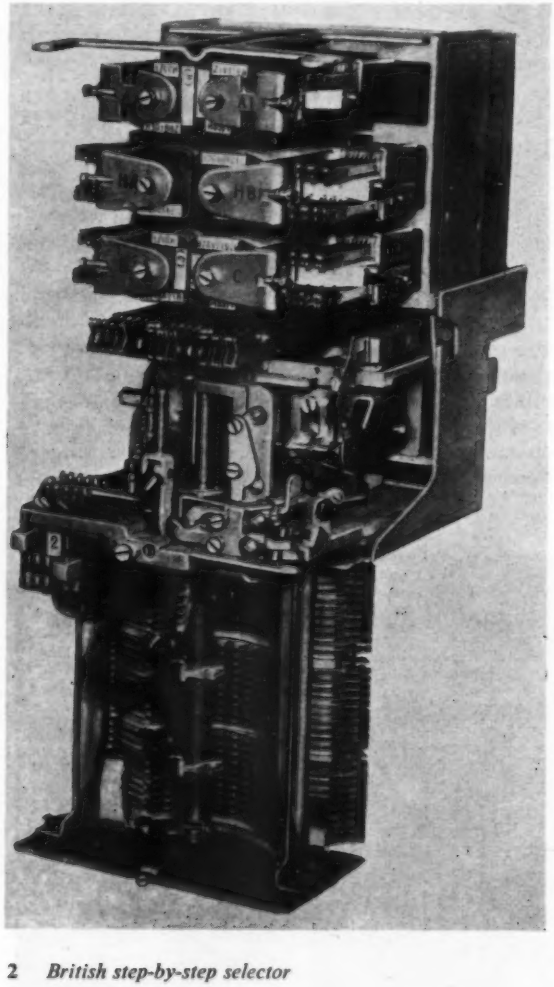
Maintaining Telephone Exchanges

A DIGEST OF A PAPER (No. 1777) ENTITLED "MAINTENANCE PRINCIPLES FOR AUTOMATIC TELEPHONE EXCHANGE PLANT," BY R. W. PALMER, MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN JANUARY, 1955, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

TO MAINTAIN an adequate quality of service from a complex automatic telephone exchange (Fig. 1) it is not enough merely to have a low numerical fault liability of each component, although this subject is worthy of serious study both in the design of mechanisms and

1 *A British automatic telephone exchange*

circuits (Fig. 2), and in the precision of maintenance adjustments. It may be found more economical to arrange that each plant fault affects fewer calls before it is detected and corrected. Thus, it is only the interwoven pattern of maintenance effort (Fig. 4, page 231) which can be said to be efficient or inefficient, and that pattern must be varied by the operating administration to suit different switching systems, different types of apparatus and even different portions of any one telephone exchange.



2 *British step-by-step selector*

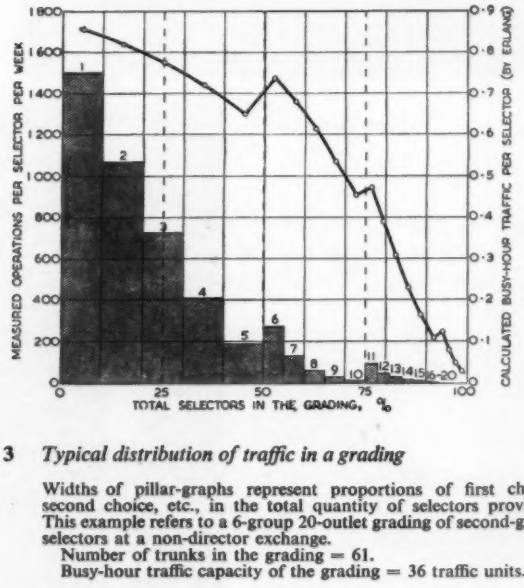
There is a strong case for concentration on prevention of faults by rapid routine tests and overhauls when

(*a*) Failure in service is serious or costly.
(*b*) Detection of service failure is difficult or slow.
(*c*) Deterioration of plant is progressive and predictable.
(*d*) Additional faults will not be caused by the preventive operations.

From this definition it follows that the greater reliability of modern apparatus and the trend away from mechanical devices and towards electronics make a preventive policy less attractive. Even the prompt correction of plant faults is less vital if facilities are provided for immediate and automatic re-routing of calls.

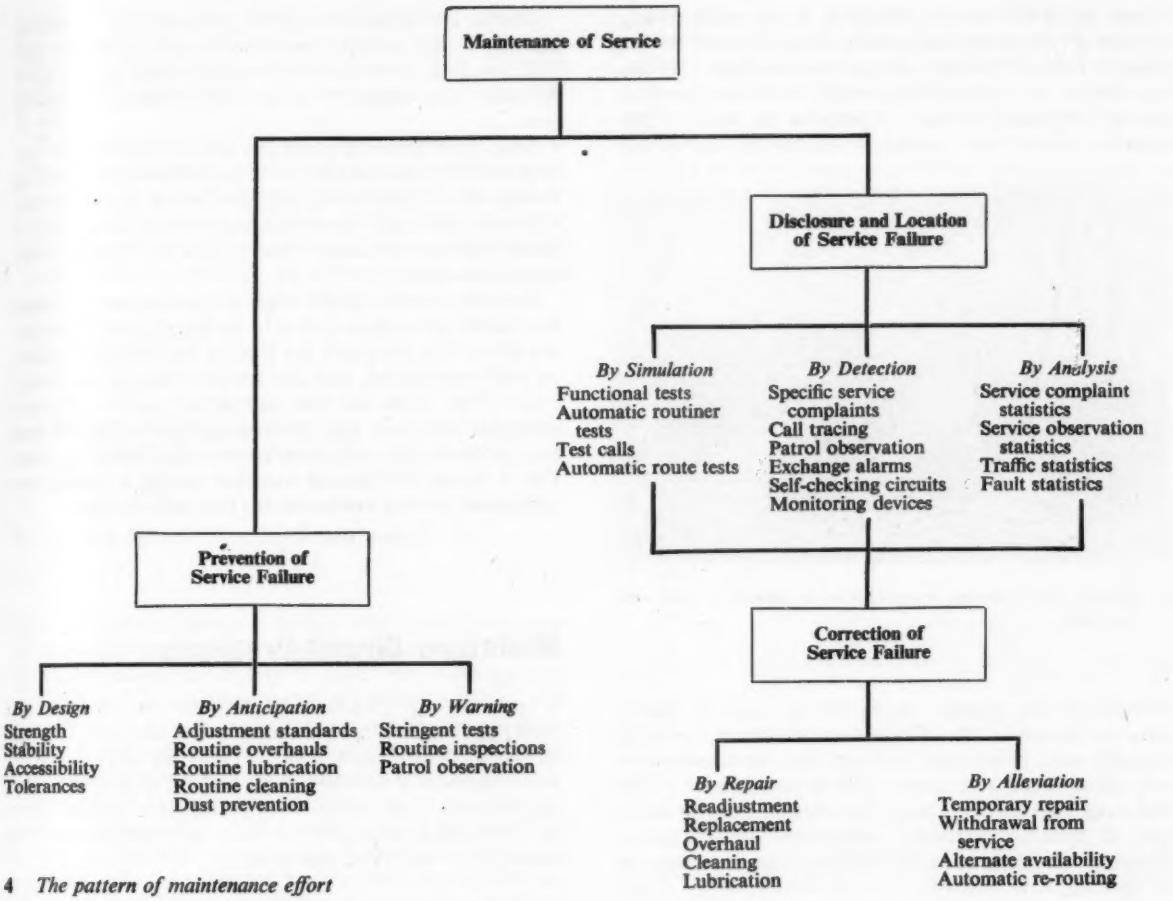
This produces a shift of emphasis towards prompt disclosures and location of service failures rather than on plant faults. The traditional maintenance tools are the functional testers. Automatic routiners are fully justified if the tests are to be applied at very frequent intervals, but the economic limit of test frequency for simple operational testing is different from that for stringent testing that is preventive in character. A more recent development is the practice of automatic route-testing (end-to-end through the exchange) with artificial traffic. An even higher standard of speed in detection of service failures is achieved in some modern systems, notably in Sweden and the United States, with the aid of self-testing circuits and automatic monitoring devices built into the switching equipment. Such devices are specially appropriate to common-control systems such as the crossbar.

Even in the more simple step-by-step systems, any rigid system of standard routines is liable to incur unnecessary work on the majority of selectors and to be inadequate for the early choices (Fig. 3). The maintenance effort must be varied locally and requires close analysis and control in the exchange itself. This "qualitative" outlook can be applied to all telephone switching systems. It not only stresses the need for economy, but makes such economy possible.



3 *Typical distribution of traffic in a grading*

Widths of pillar-graphs represent proportions of first choice, second choice, etc., in the total quantity of selectors provided. This example refers to a 6-group 20-outlet grading of second-group selectors at a non-director exchange.
Number of trunks in the grading = 61.
Busy-hour traffic capacity of the grading = 36 traffic units.

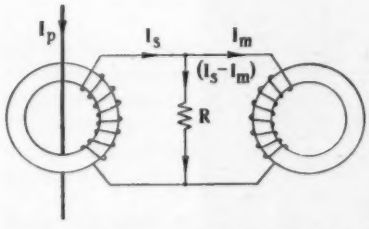


4 *The pattern of maintenance effort*

Current Summations with Current Transformers

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1678) WITH THE ABOVE TITLE BY A. HOBSON, M.SC.TECH., MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN JUNE, 1954, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

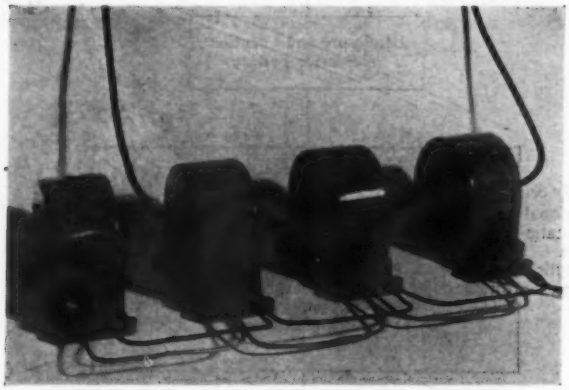
THE USE OF CURRENT TRANSFORMERS to sum the currents in a number of supply lines is often regarded with some suspicion, because of the supposed effect of idle feeders on the accuracy. In Fig. 1, for example, only the left-hand transformer is carrying load, and it is clear that part of its output is diverted from the burden to provide a magnetizing current for the idle secondary of the other. If the latter were disconnected the accuracy of the measurement would be improved—hence the doubts as to the validity of the method.



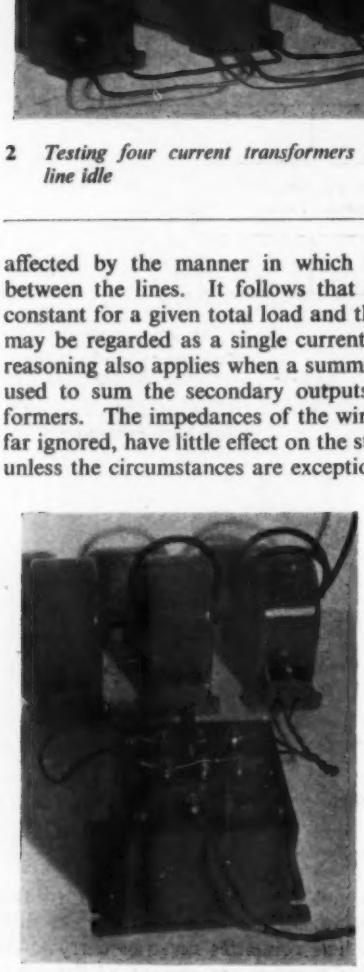
1 *Parallel current transformers with one line idle*

However, this is not a complete approach to the problem. Current-transformer secondaries are not disconnected when their primaries cease to carry load, and their magnetizing currents are present all the time. The really important thing is that the overall accuracy should be stable for a given total load, and should not vary according to the current distribution.

Now the total error is the sum of the magnetizing currents of the two transformers, which depend on the voltages induced in their secondary windings. If the impedances of the windings and leads are ignored, exactly the same voltage is induced in each. This depends only on the current in the burden and is not affected by the manner in which the load is shared between the lines. It follows that the overall error is constant for a given total load and that the combination may be regarded as a single current transformer. This reasoning also applies when a summation transformer is used to sum the secondary outputs of the line transformers. The impedances of the windings and leads, so far ignored, have little effect on the stability of the errors unless the circumstances are exceptional.



2 *Testing four current transformers in parallel, with one line idle*



3 *Testing set-up for a 3-circuit summation transformer equipment, with line transformer ratios 100/5, 200/5 and 300/5 amp*

Contrary to existing thought, it seems that the actual position of the parallel connection does not matter, but it is important that all the line transformers should have the same percentage of turns compensation, preferably zero.

Tests were made to verify the above theories. In one of them four transformers were paralleled and tested as a single unit, first with equally distributed load and then with one, two and three idle lines respectively. Fig. 2 shows the method used. The four sets of results were almost identical.

Once the stability of the methods have been established the circuit parameters prove to be simple, and formulae are derived in the paper for finding the effective burden on each transformer, and also for determining the overall error from tests on the individual units. Worked examples are given, with confirming test results, for both parallel-secondary and summation-transformer systems. Fig. 3 shows the method used for testing a summation equipment having unequal-ratio line transformers.

Miniature Circuit-Breakers

A DIGEST OF A UTILIZATION SECTION PAPER (No. 1745) ENTITLED "DESIGN, PERFORMANCE AND APPLICATION OF MINIATURE CIRCUIT-BREAKERS," BY H. W. WOLFF, B.SC., ASSOCIATE MEMBER, AND T. G. F. ATHERTON, B.A., GRADUATE. THE PAPER WAS PUBLISHED SEPARATELY IN DECEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

ALTHOUGH MINIATURE CIRCUIT-BREAKERS have been manufactured since before 1910, and although in America they have occupied a place of prime importance for the last 25 years in the field of circuit protection, their application in Great Britain has been surprisingly slow. The underlying reasons for this may no doubt be found to some extent in the last war, and in the somewhat conservative outlook of the British engineer and contractor, but other causes are of a technical and economic nature.

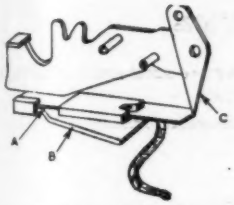
No one is likely to dispute the advantages possessed by miniature circuit-breakers as regards convenience, quick restoration of supply and safety, but the engineering problems involved are such as to make a satisfactory design that is both functionally and economically acceptable a proposition of some difficulty.

In the first place, to find general acceptance for distribution circuit protection, the size must be such as to make the circuit-breaker acceptable in lieu of a fuse of comparable rating. Furthermore, provision for mounting and wiring must allow for building circuit-breakers into distribution boxes.

In the second place, electrical performance must satisfy various requirements from the point of view of

temperature rise, time delay and rupturing capacity. Temperature rise will not usually present serious difficulties, the almost universal use of butt contacts with wiping and/or rolling action ensuring a fair efficiency in service.

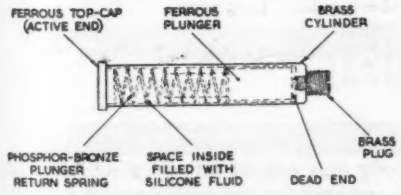
The necessity for a time-delay device in most applications presents several complications. The design must be such as to absorb starting and switching surges and permit small harmless overloads, while operating on the occurrence of serious over-currents; it must also provide "instantaneous" tripping on short-circuit. The open



1 *Combined bimetal thermal trip and magnetic trip*

type of electromagnetic dashpot trip is obviously unsuitable for use in miniature circuit-breakers, but hermetically sealed dashpot units have been developed to provide both time-delay and instantaneous trips. On the other hand, wide use is being made of thermal trips, either directly or indirectly heated, together with some provision for electromagnetic instantaneous tripping.

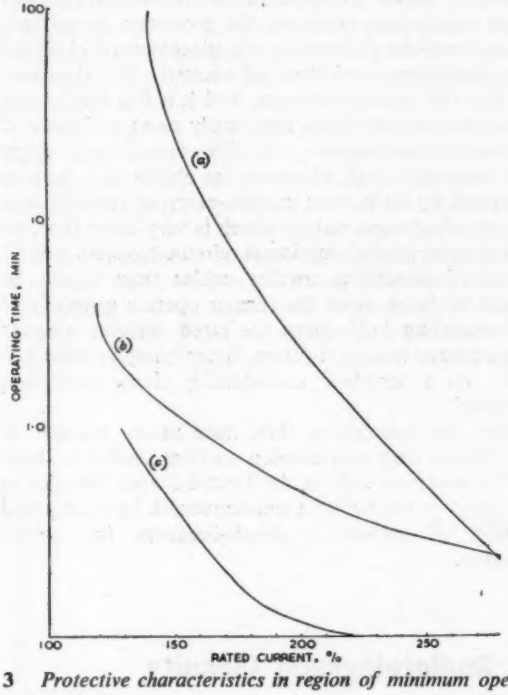
The extent of short-circuit protection to be provided is a debatable point. The general present-day tendency is to design switchgear with ever-larger rupturing capacity. On the other hand, experience has shown that on distribution sub-circuits, where the bulk of applications lie, the prospective short-circuit current exceeds 1 500amp only in rare instances, and, in fact, lies often below 500amp. The feeling has therefore grown that it is not always desirable to sacrifice other technical and economic advantages in order to achieve a high rupturing capacity,



2 *Sealed magnetic-hydraulic time-delay unit*

as proved by some designs of almost minute dimensions and very low short-circuit capacity. Where the prospective short-circuit current exceeds the capacity of the circuit-breaker, the latter ought to be backed up with a cartridge fuse, or, better still, with another circuit-breaker of higher rupturing capacity.

The third major point to be considered is that of operational life. Whereas a large circuit-breaker is unlikely to be used as a switch in service, this is not so with miniature circuit-breakers, particularly where they are used in lieu of a combination of switch and fuse. The large "life" figures achieved with some types of tumbler switches (over one million operations) have so



3 *Protective characteristics in region of minimum operating current*

(*a*) Class-Q h.r.c. fuses.
(*b*) Miniature circuit-breaker with thermal delay.
(*c*) Miniature circuit-breaker with hydraulic-magnetic delay.

far not been obtained or even aimed at, but values up to 100 000 operations have been achieved and have proved amply sufficient for practical purposes.

A fourth point of considerable weight is the economic factor. It is, in fact, in many cases the controlling factor, particularly when it comes to domestic applications,

Some indications of the initial price discrepancies of Fuse, Switch-Fuse and Circuit-Breaker Panel Boards in the United States

Number of ways	Relative costs		
	Fuse	Switch-fuse	M.C.B.
4	100	202	211–229
16	151	357	373–460
20	169	408	404–536
32	355	560	624–767
40	408	660	686–920

where the operational advantages may not necessarily be thought to outweigh any great difference in initial cost.

In this connection an existing gap could doubtlessly be filled by a new functional design, aiming at a small, simplified, mass-produced circuit-breaker with a minimum number of parts, perhaps rated at 250 volts a.c. only (instead of the existing a.c./d.c. designs).

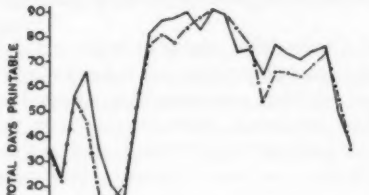
When it comes to applications in industrial, commercial and public premises, the economic advantages resulting from the elimination of replacements and skilled maintenance personnel must, of necessity, be taken into account when comparing costs, and it is felt that in this instance the balance sheet may easily point in favour of miniature circuit-breakers. In this connection it ought to be mentioned that, whenever the choice of a cable is determined by its normal current-carrying capacity and not by its short-time rating (which is very often the case on final sub-circuits) miniature circuit-breakers permit the use of somewhat smaller cables than would be required by fuses, since the former operate generally at loads exceeding 1·25 times the rated current, whereas the latter have usually a fusing factor lying between 1·5 and 2. As a corollary, considerably closer protection is possible.

There are indications that installation practice in Great Britain may well develop on lines similar to those now followed, not only in the United States, but also in many parts of the British Commonwealth by widespread adoption of miniature circuit-breakers for circuit protection.

H.F. Radiotelegraph Circuits

A DIGEST OF A RADIO SECTION PAPER (No. 1787) ENTITLED "PERFORMANCE CHARACTERISTICS OF HIGH-FREQUENCY RADIOTELEGRAPH CIRCUITS," BY A. M. HUMBY, ASSOCIATE MEMBER, C. M. MINNIS, M.SC., F.INST.P., AND R. J. HITCHCOCK, B.A., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN JANUARY, 1955, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

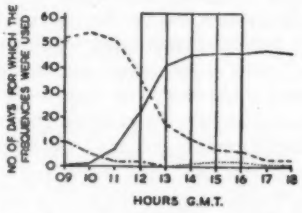
RADIOCOMMUNICATION in the high-frequency bands is closely controlled by conditions in the ionosphere. Although it is now possible to make advance forecasts of the frequency bands which can be used for any given circuit, it is much less easy to estimate the performance of a circuit in terms of the percentage of time for which it can be used for communication purposes. However, the practical experience gained since the introduction of the high-speed telegraph Empire beam circuits in 1927, and the later addition of other commercial and military circuits, has allowed the performance of these circuits to be related to the long-term changes in ionospheric characteristics and solar activity. It is worth noting that, when two circuits using first-class equipment are operated by two different organizations over the same route, the effects of differences in the equipment, personnel and other factors are usually small compared with those due to ionospheric control (Fig. 1).



1 *Comparison of performance over the same route of circuits operated by different organizations*

Colombo–London. November, December, January, 1952–53.
———— Admiralty.
—·—·—·— Air Ministry.

The analysis of the circuit data has disclosed several features of circuit performance for which no full explanation can yet be given. For example, during the winter afternoons of 1936–39 the Buenos Aires–London circuit was operated over the long route, which passes near to Tokyo, on a frequency of 17 Mc/s. At the same time, a much lower frequency had to be used for the Tokyo–London circuit (Fig. 2). The fact that a section more



2 *Comparison of frequency usage over the whole and part of the Buenos Aires–Tokyo–London route; winter 1936–37*

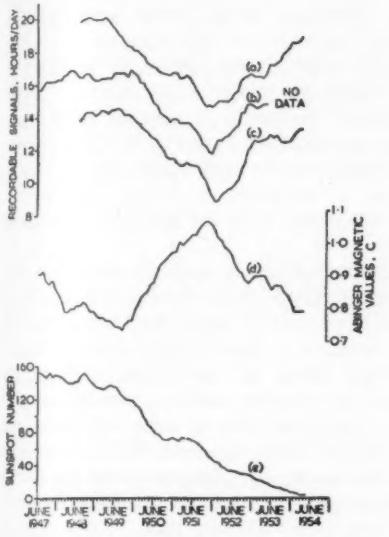
Period when the frequency of 17 Mc/s was in regular use. Buenos Aires–London. Long route.
..... 7 Mc/s
———— 9 Mc/s
– – – – – 13 Mc/s
—·—·—·— 18 Mc/s
} Tokyo–London.

than 4 000 km long may require an operating frequency lower than that required for the whole circuit suggests, on the latter, the possibility of modes of propagation which do not involve a reflection at the earth's surface.

Fig. 3 relates the performance of several circuits to solar and geomagnetic activity. In general, the performance is low at sunspot minimum, mainly because of the narrow frequency band which can be used and the comparatively high rate of occurrence of magnetic disturbances. Nevertheless, the worst performance may be found to occur, not at sunspot minimum, but during the

period a few years earlier when the incidence of M-region magnetic storms reaches a maximum, such as in 1952.

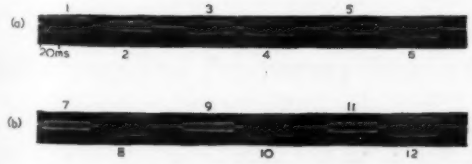
The use of relay stations is valuable as a means of avoiding the auroral zone on circuits traversing high latitudes, but it is necessary to ensure that the advantages



3 *Relationship between circuit performance and magnetic and solar activity (12 months' running means)*

(*a*) Halifax–London.
(*b*) Melbourne–Montreal.
(*c*) Harman (Canberra)–London.
(*d*) Magnetic activity at Abinger, *C*.
(*e*) Solar activity.

of a low-latitude relay station are not lost because of a high local noise-level. Also it is useful to site relay stations in such a way that the circuit may be operated either over the light or dark hemisphere of the earth. This minimizes the amount of time lost due to sudden



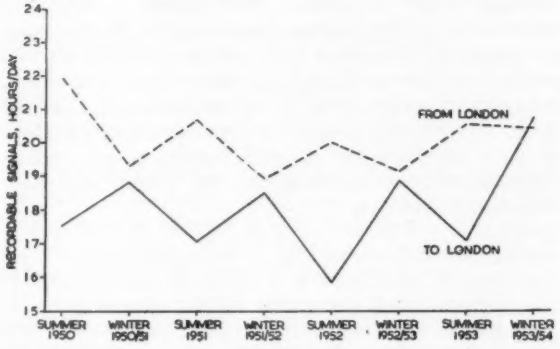
4 *Differential fading of signals received in London from Singapore via the short and long routes*

Odd numbers: Short route signals.
Even numbers: Long route signals.

ionospheric disturbances in the daylight hemisphere which are often troublesome near sunspot maximum.

The harmful effects of echo signals of various kinds in reducing the readability of modern high-speed telegraph signals are not always appreciated. For example, when signals of comparable field strength arrive at the receiver by the long and short great-circle routes, the printed signal may be quite unintelligible. Fig. 4 shows test transmissions producing several pairs of long- and short-route signals and the differential fading which results in first the short-route and then the long-route signals being the greater. The diagnosis of the presence of echoes on radiotelegraph circuits is discussed in the paper, together with recommendations for minimizing their effects.

It has been found that on many circuits there is a systematic difference in the performance of a circuit in the incoming and outgoing directions. This might, not unreasonably, be attributed to permanent differences in the equipment or in the efficiency of the staff at the terminal stations. However, it has been noticed that, in addition to this long-term asymmetry in performance, there is frequently a superposed seasonal change in performance which is opposite in sign in the two directions. One example of this seasonal change in asymmetry and a small amount of long-term asymmetry is illustrated in Fig. 5. It is not yet possible to account for the seasonal



5 *Seasonal changes, which are opposite in sense for the outgoing and incoming directions, in the performance of the London–Simonstown (Cape Town) circuit*

— — — — London–Simonstown.
——— Simonstown–London.

changes, but they are not likely to be due to corresponding changes in the equipment or the staff. It is possible that seasonal changes in the noise level in the vicinity of the receiver may be at least partly responsible, but very little information is available on the noise level as measured on the highly directive receiving aerials in use; the data contained in the usual noise-level charts are strictly applicable only to omnidirectional aerials. Seasonal asymmetry could also be caused by the combined effects of tilts in the ionospheric reflecting layers and differences in the receiving aerial polar diagrams. It is also conceivable that propagation in the ionosphere may not be reciprocal, but this is not at present considered to contribute materially to the observed effects.

Time Loss on Transatlantic Radio Circuits

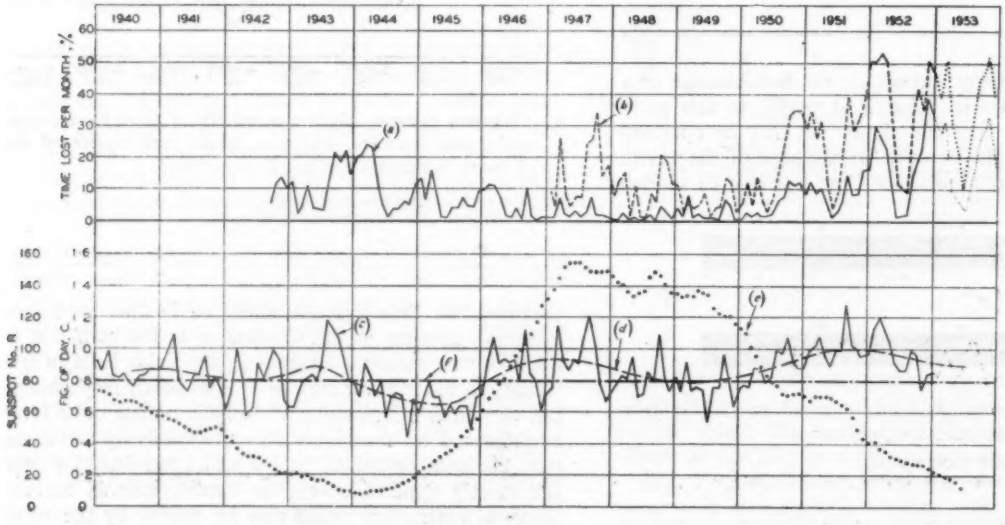
A DIGEST OF A RADIO SECTION PAPER (No. 1708) ENTITLED "A STUDY OF COMMERCIAL TIME LOST ON TRANSATLANTIC RADIO CIRCUITS DUE TO DISTURBED IONOSPHERIC CONDITIONS," BY J. K. S. JOWETT, B.SC.(ENG.), AND G. O. EVANS, B.SC., ASSOCIATE MEMBERS. THE FULL PAPER WAS PUBLISHED SEPARATELY IN OCTOBER, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

THE PECULIAR DIFFICULTIES of long-distance high-frequency communication arise, as is well known, from the large variations in the state of the earth's ionosphere, which is responsible for the reflections back to the ground of the radio signals. While much evidence has now been accumulated as to the way in which the characteristics of radiocommunication over different routes vary through the day and with the seasons of the year, less evidence has been gained, or at least reported, over periods subtending a complete sunspot cycle, normally about 11 years. Furthermore, quantitative information is also lacking concerning the sudden and, on occasions, prolonged interruptions to radio circuits which arise due to ionospheric disturbances and affect, in particular, routes crossing high-latitude regions of the earth. The paper is largely concerned with the occurrence of such interruptions to radiotelephone and radiotelegraph circuits incoming to the United Kingdom from North America.

Some features of these interruptions, as observed over periods from 1942 onwards, are discussed in the paper. Thus there is the generally close connection between the incidence of magnetic storms (i.e. larger-than-usual variations in the earth's magnetic field) and the occurrence of difficulties in radio-circuit performance; this is well illustrated at the equinoxes, when circuit interruptions are regularly more marked. It also appears that the time lost on these radio circuits generally reaches a maximum in the declining phase of the sunspot cycle rather than at sunspot maximum or sunspot minimum. During this declining phase of the solar cycle, ionospheric disturbances, magnetic storms and radio-circuit interruptions all show a pronounced 27-day recurrence tendency, clearly associated with the period of rotation of the sun.

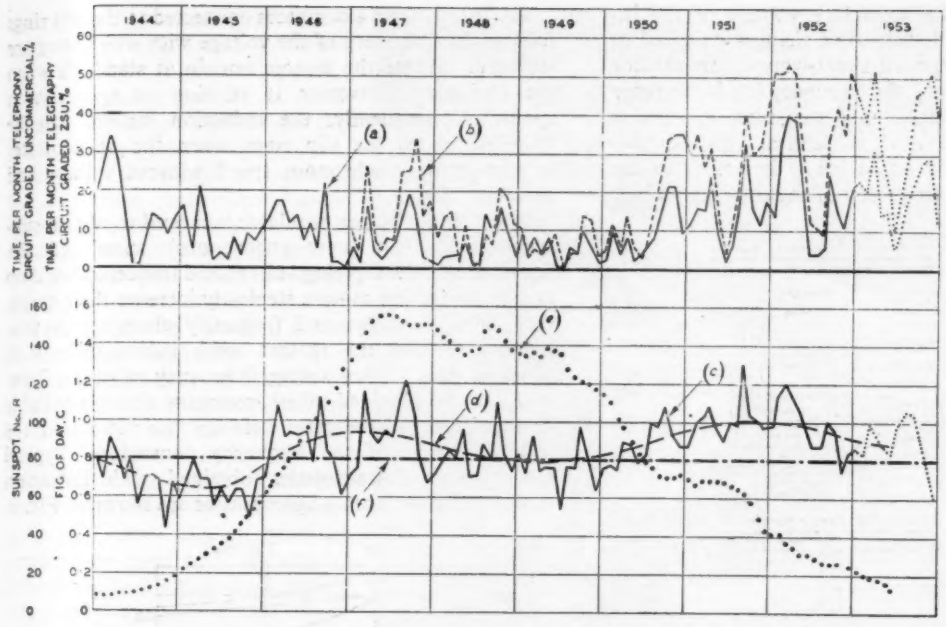
The commercial time lost on transatlantic radio circuits did not reach serious proportions during the sunspot cycle now virtually completed until September 1950, when a sudden increase in circuit interruptions took place, the difficulties being very pronounced at night time. Apart from the summer months, conditions on these circuits have remained difficult since that date, as is shown in Figs. 1 and 2, although more recent evidence in 1954 suggests that some slight improvement has now set in. It will be noticed that conditions during the past few years have been more difficult than in the corresponding period of the previous sunspot cycle, despite advances in equipment technique which have been made in the interval.

When this study was commenced in 1952 it was desired to forecast the probable trend of performance of these



1 *Percentage of scheduled time on New York–London (high-power system using m.u.s.a. reception) and Montreal–London telephony circuits (incoming direction only), and variations in solar and magnetic activity*

(*a*) New York–London.
(*b*) Montreal–London.
(*c*) Abinger magnetic figure of the day, *C*.
(*d*) Yearly average of *C*.
(*e*) Zürich sunspot number, *R*.
(*f*) Arbitrary reference level.



2 *Percentage of scheduled time lost on Montreal–London telephony and telegraphy circuits (incoming direction only), and variations in solar and magnetic activity*

(*a*) Telegraphy circuit.
(*b*) Telephony circuit.
(*c*) Abinger magnetic figure of the day, *C*.
(*d*) Yearly average of *C*.
(*e*) Zürich sunspot number, *R*.
(*f*) Arbitrary reference level.

circuits over the following few years. From the evidence available up to the end of 1953, and with the expectation that sunspot minimum conditions would persist at least until the end of 1954, it was concluded that circuit conditions would remain very difficult over the winter of 1953–54 and some slow improvement might occur during 1954, mainly due to the probable reductions in ionospheric disturbances. These expectations have been largely fulfilled, and it is expected that any great improvement in circuit conditions must await the definite commencement of a new sunspot cycle, possibly in 1955.

Self-Propelled Frequency Convertor

A DIGEST OF A UTILIZATION SECTION PAPER (No. 1766) ENTITLED "THE THEORY AND APPLICATION OF A SELF-PROPELLED STATOR-FED FREQUENCY CONVERTOR," BY B. SCHWARZ, D.SC.TECH., DIPL. ING., MEMBER. THE FULL PAPER WAS PUBLISHED IN FEBRUARY, 1955, IN PART A OF THE PROCEEDINGS.

THE INTRODUCTION OF A.C. SUPPLY SYSTEMS has resulted in the general acceptance of the induction motor, particularly with the squirrel-cage rotor, which is inherently a constant-speed machine.

The steadily increasing demand for variable-speed drives arising from the requirements of production and process controls has resulted on the one hand in the development of suitable a.c./d.c. conversion equipment to enable the application of speed-controlled d.c. motors and on the other hand in the successful development of a.c. commutator motors connected direct to the a.c. supply, which are available now for wide output and speed ranges.

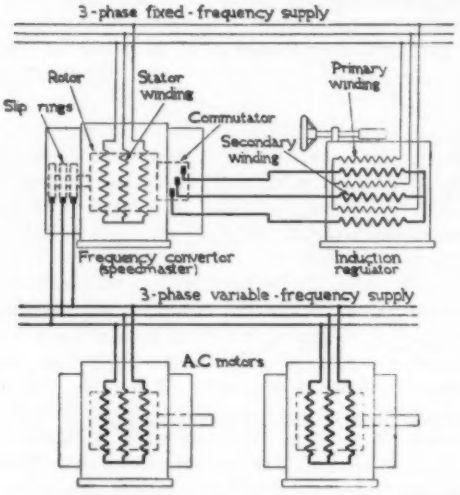
A "variable-speed squirrel-cage motor," however, has been a desirable aim for a long time for such applications where the mechanical conditions and the location of the drive exclude the use of commutators, whether a.c. or d.c., and for such drives where a number of motors have to be simultaneously controlled in speed.

The paper contains the description, theory and application of a self-contained frequency convertor, which produces an adjustable and variable frequency that can be utilized to obtain speed control of a.c. induction and synchronous machines through frequency variation.

Fig. 1 shows the basic arrangement of an equipment containing the Speedmaster, which is a self-propelling commutator frequency convertor with its stator connected to the supply and its commutator with its fixed brush system connected to a variable voltage supply derived from an induction regulator.

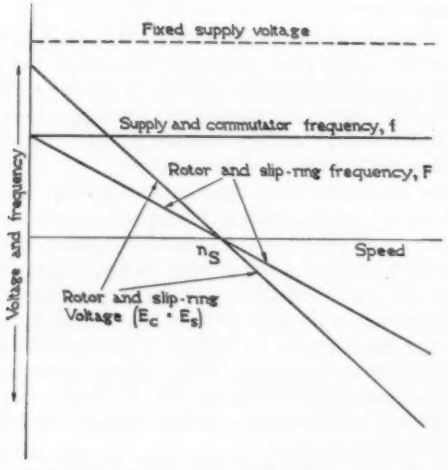
The rotor winding of the Speedmaster is connected to the commutator on the one hand and has tappings connected to a set of slip rings on the other hand. One or more a.c. motors are supplied from these slip rings.

By adjustment of the secondary voltage of the induction regulator, the Speedmaster changes its speed in the same way as a stator-fed shunt-wound commutator motor. At the same time, the frequency inside the rotor winding changes in sympathy, so that there appears at the slip rings a voltage which is identical with the commutator voltage, both voltages being derived from the same winding; but the frequency of the slip-ring voltage



1 *Block schematic of basic arrangement of frequency-convertor set with a.c. motor load*

is variable, whereas the frequency of the voltage supplied to the commutator remains constant. These conditions are shown in Fig. 2.

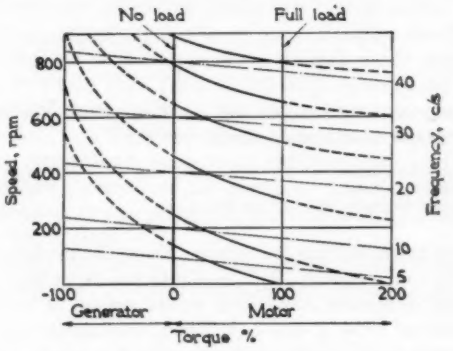


2 *Voltage and frequency variation at commutator and slip rings*

The ratio of slip-ring voltage to slip-ring frequency E_s/F is constant. n_s = Synchronous speed.

The speed of the a.c. motors connected to the slip rings follows the frequency of the voltage with which they are supplied. Hence the motors remain at standstill when the frequency convertor is running at synchronous speed. Consequently, the induction motors can be switched on to the slip rings when the Speedmaster is running at synchronous speed without voltage and current.

When the induction regulator is moved to obtain sub-synchronous (or super-synchronous) speed of the Speedmaster, the slip-ring voltage and frequency build up and the induction motors steplessly increase their speed, their supply voltage and frequency changing in proportion so that the motors work substantially with constant flux. Other voltage/frequency relations, however, can be obtained where necessary through suitable arrangements of the ratio between the rotor and the stator voltages of the frequency convertor. Typical torque/speed characteristics obtained with induction motors supplied from a Speedmaster are shown in Fig. 3.



3 *Torque/speed curves (for various regulator adjustments) of a 60 h.p., 6-pole, 40 c/s motor supplied by a 50 kVA, 40 c/s (max) convertor*

The above calculated torque/speed curves have been substantiated by tests.
– – – – – – Lines of constant frequency.

The losses involved in the frequency-conversion system are low, as the commutator and slip-ring currents virtually cancel each other out, so that for the case of a 6/6 phase conversion, i.e. with the commutator fed with three open phases and the slip rings supplying two systems of 3-phase motors, the rotor copper losses are only 17% of those which the same current would produce in a commutator or slip-ring winding.

The current drawn from the constant-frequency supply reflects virtually in proportion with the frequency ratio the current required by the motors, so that, even with heavy starting torques at low frequencies, less than the full-load current of the set is taken from the supply.

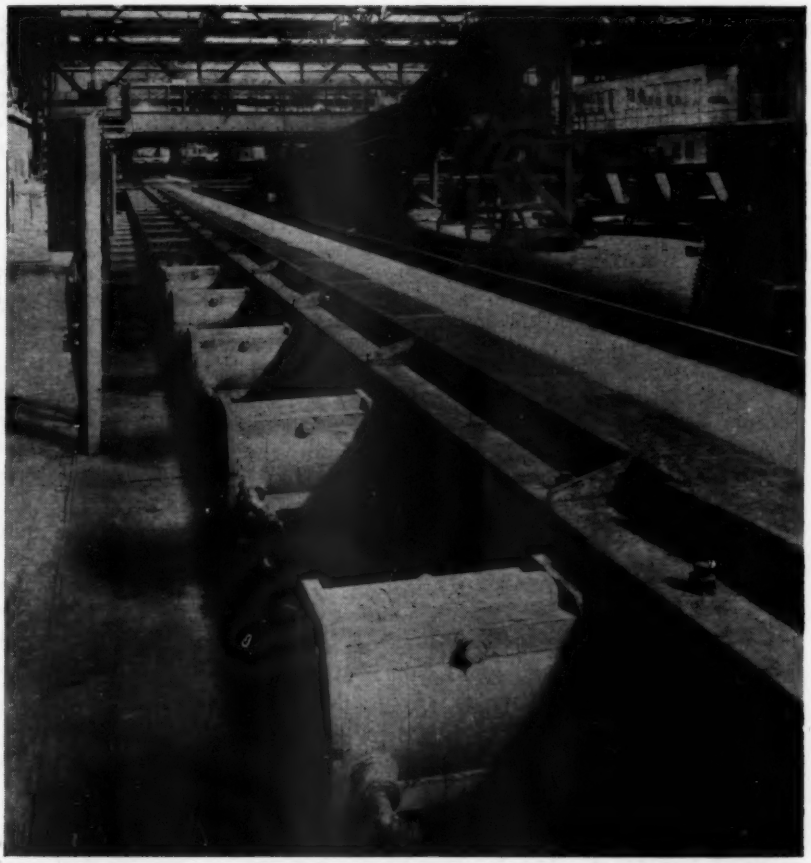
Any number of motors can be controlled in speed by one Speedmaster, provided that it is designed for the required output, and in practical installations more than 80 motors are fed by one Speedmaster, the case in

question being the individual roller-table motors of a hot-run-out table for a large aluminium rolling mill.

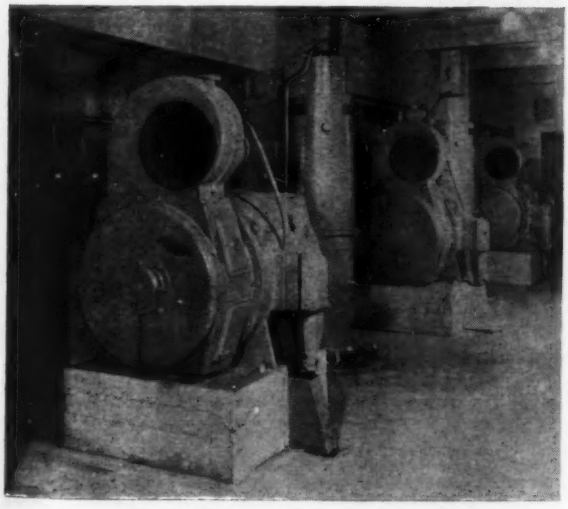
Fig. 4 shows part of a roller table in a Swedish steel works, the roller-table motors being supplied, in different groupings as required by the process, from three Speedmasters, shown together with their induction regulators in Fig. 5.

The fact that the induction motors are started at low frequency and brought up to operating speed by frequency variation reduces their heating losses to a fraction of those which would be developed by direct-on starting, so that plain totally enclosed motors can be employed in the case illustrated for 600 plugging and inching operations per hour. Other practical applications have been conveyors, processing lines for the steel, metal, printing, pottery, food and other industries.

Load sharing is obtained with induction motors through their inherent slip. Where absolute synchronization is required, synchronous motors are being used, and for cases of relative synchronization, e.g. in a process line, where there is a reeler drive, the latter is driven by a commutator motor supplied from the Speedmaster which feeds the induction motor of the group. The commutator motor can be a shunt machine with its induction regulator providing the relative speed adjustment, or a series motor with an inherent torque/speed characteristic suitable for obtaining constant tension in the material.



4 *Floating type a.c. induction motors driving steel-works live rolls, operating at 150/60 r.p.m. from 22/10 c/s supply*



5 *Three Speedmasters supplying 22/10 c/s roller-table motors.*
The induction regulators are arranged for high-speed control giving 600 plugging and inching operations per hour on the roller tables

Any required type of automatic control can be applied to a Speedmaster to suit the needs of the group drive supplied, including the synchronization of such groups.

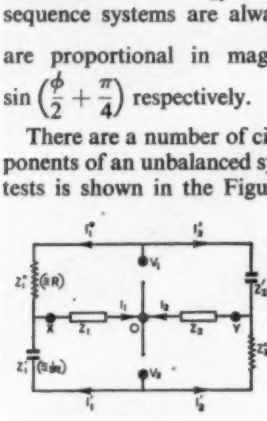
Symmetrical Components in Single-Phase Circuits

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1758) ENTITLED "THE APPLICATION OF SYMMETRICAL COMPONENTS TO THE MEASUREMENT OF PHASE DIFFERENCE IN SINGLE-PHASE CIRCUITS," BY R. L. RUSSELL, M.SC., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN FEBRUARY, 1955, IN PART A OF THE PROCEEDINGS.

THE FUNDAMENTAL THEOREM in symmetrical-component analysis is employed almost exclusively in 3-phase systems

and only infrequently in other cases. In his paper Mr. Russell uses the bi-phase (90°) or so-called 2-phase form. This is, more precisely, half a 4-phase system containing no zero-sequence component. In these terms, any two single-phase voltages V_1 and V_2 can be regarded as an unbalanced bi-phase system and can be resolved into two balanced bi-phase systems of opposite phase rotation. In particular, when V_1 and V_2 are equal in magnitude and have a relative phase displacement ϕ, the reference vectors V_{a1} and V_{a2} in the two resolved sequence systems are always in phase quadrature and are proportional in magnitude to $\cos\left(\frac{\phi}{2}+\frac{\pi}{4}\right)$ and $\sin\left(\frac{\phi}{2}+\frac{\pi}{4}\right)$ respectively.

There are a number of circuits for separating the components of an unbalanced system, and the one used in the tests is shown in the Figure. Both the capacitors and



Four-element bridge

$R = Z_1' = Z_2' = 1400$ ohms; $Z_1' = Z_2' = 1/\omega C$: $C = 2{\cdot}275\,\mu$F, at 50 c/s.

$V_1 = V_2 = 40$ volts. Z_1 and Z_2 are equal load impedances.

the resistors have the same numerical impedance. The values of the load impedances Z_1 and Z_2 are not important provided that they are equal. The voltages appearing across OX and OY are proportional to the reference voltages V_{a1} and V_{a2} respectively, but they have a phase displacement of 90° in addition to that which exists between V_{a1} and V_{a2}. When, therefore, the reference vectors in the sequence components are in phase quadrature, the measured voltages corresponding to them will be in phase.

In one application, the X- and Y-plates of a cathode-ray oscillograph are connected between OX and OY respectively, and a linear trace of constant length, at an angle $\left(\frac{\phi}{2}+\frac{\pi}{4}\right)$ to the horizontal, is produced. The phase angle is read from an evenly divided transparent scale, each half of which is calibrated from 0° to 360°, attached to the face of the tube. Alternatively, two identical magnetic deflecting coils, set at right angles on the neck of the cathode-ray tube, could be employed instead of the deflector plates.

The error in measuring the phase displacement between the two applied voltages in this way does not exceed 2°, and the method is thought to be more accurate, in relation to its extreme simplicity, than others previously described. The accuracy does not depend on the long-term stability of preset components, and the bridge circuit is easily adjusted, without reference to external standards or measurements, by using the cathode-ray oscillograph as an indicator. The paper considers the effects of harmonics and inequalities in applied voltages V_1 and V_2 and shows that they are not serious.

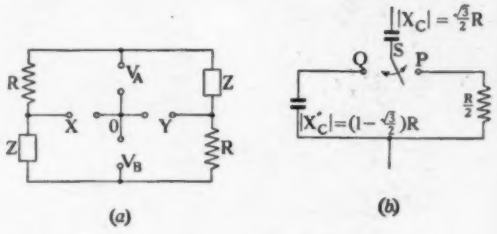
In a second application, an instrument of the ratiometer type is used in place of the cathode-ray oscillograph. One stator winding is connected across OX and the other across OY. The error in detecting ϕ in this instance is rather less than 2°.

Phase Rotation of Polyphase Systems

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1789) ENTITLED "THE DETERMINATION OF PHASE ROTATION OF POLYPHASE SYSTEMS," BY R. L. RUSSELL, M.SC., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN FEBRUARY, 1955, IN PART A OF THE PROCEEDINGS.

THERE ARE NOT MANY METHODS for determining the phase rotation or phase sequence of a 3-phase system, yet this information is frequently required in installations practice. One method employs two lamps and a capacitor (or choke) which are connected in star and supplied from the 3-phase system to be tested; the phase rotation of the applied system determines which of the two lamps shall be the brighter. This method, first devised by T. W. Varley some 40 years ago, provides a popular laboratory exercise and is the one most commonly described, but it is not much used in practice. Modifications to the basic circuit have achieved an improved performance at the expense of simplicity, which was the chief merit of the original method.

The method described in the paper depends on symmetrical-component principles. In general terms, a balanced polyphase system with a conventional phase rotation has a zero negative-sequence component. When the phase sequence is reversed, the system will consist wholly of a negative sequence and there will be no positive sequence component.



(a) (b)

1 *Phase-sequence selective circuit*

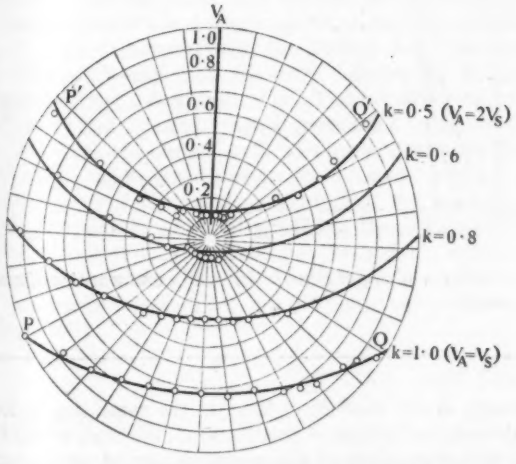
(*a*) Schematic.
V_A and V_B are reference and succeeding vectors respectively in the applied voltage system. The positive-sequence component voltage is established across OX; the negative-sequence component across OY.

(*b*) Circuit and switching arrangements, for each of the impedances Z in Fig. 1(*a*), for a combined 3-phase and bi-phase (90°) network. With change-over switch S on P, the 3-phase condition $R = -a^2Z$ is satisfied; with S on Q, the bi-phase relation $R = jZ$ is obtained.

Fig. 1(*a*) shows a simple sequence discriminating circuit in which V_A and V_B are consecutive members of a polyphase system, and the positive- and negative-sequence components appear between O and X, and O and Y, respectively. When designed for a 3-phase system, a voltage equal to the applied voltage is established between O and X, and there is no voltage between O and Y when V_B lags V_A by $2\pi/3$. The reverse is true when V_B leads V_A by $2\pi/3$. Neon indicator tubes are connected between O and X and O and Y, but tungsten-filament lamps, relays or rectifier meters could have been employed instead. The lamp across OX will light in the former case and that across OY in the latter.

The bridge circuit can be used for systems other than the one for which it was specifically designed. A voltage will then be obtained across one of the indicators when ideally there should be none, but the relative brightness of the lamps gives a reliable determination of the phase-rotation. Alternatively, optimum conditions can be assured by including a selector switch to choose circuit constants appropriate to the system being tested, and Fig. 1(*b*) shows the form taken by each of the impedances in Fig. 1(*a*) for a combined 3-phase bi-phase (90°) bridge.

The method is a versatile one, requiring only a few components which are easily assembled and adjusted. The device will tolerate wide variations in applied frequency, it is not sensitive to harmonics and a reliable indication continues to be given when the applied system is unbalanced. A chart of the kind shown in



2 *Chart for estimating the response of the indicator to an unbalanced voltage system* ($k = V_S/V_A$)

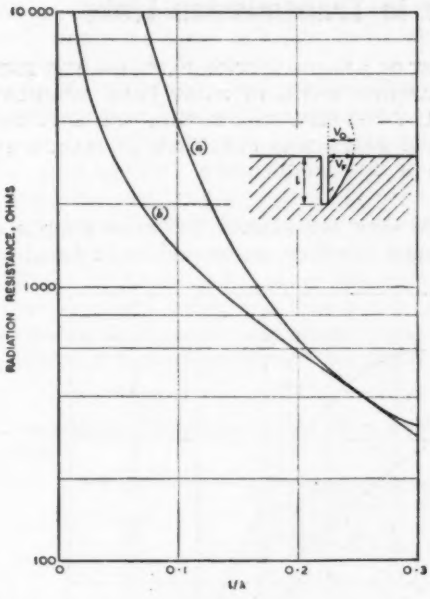
Fig. 2 can be used to predict the effect of an unbalanced supply for different values of the applied voltage and the neon-tube striking voltage.

The Notch Aerial

A DIGEST OF A RADIO SECTION PAPER (No. 1742) ENTITLED "THE NOTCH AERIAL AND SOME APPLICATIONS TO AIRCRAFT RADIO INSTALLATIONS," BY W. A. JOHNSON, M.A., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN MARCH, 1955, IN PART B OF THE PROCEEDINGS.

A METALLIC SHEET can be excited as an aerial by means of a notch cut into its edge and suitable coupling to a feeder cable; the paper discusses the radiation resistance, the reactance, and the radiation pattern of this type of aerial.

For a rectangular notch cut in a semi-infinite sheet the radiation resistance R_F of the notch is given in Fig. 1.



1 *Radiation resistance of notch aerials*
(*a*) R_0: referred to voltage loop.
(*b*) R_F: referred to top of notch.

Experiments have shown that this result is applicable with sufficient accuracy for engineering purposes to structures such as aircraft wings, provided that the thickness near the notch is small compared with a wavelength and that the structure extends around the notch for a distance of the order of one wavelength.

The radiation pattern depends on the shape of the supporting structure, its size relative to wavelength and the position of the notch. Various theoretical and practical examples of radiation patterns which can be obtained are given. For instance, a notch in an aircraft wing-tip has given a radiation pattern suitable for a radio approach aid in the frequency band 108–112 Mc/s,

which requires substantially omnidirectional cover for horizontally polarized signals. A notch near the wing root, while giving a polar diagram far from circular, has proved quite useful for h.f. communication.

The only insulating material required in an aircraft installation is a fairing to restore the contour of the wing. There is no structural problem of supporting a load-carrying metallic member on insulating material, and then protecting this insulated structure against lightning or accumulation of static charge. While some increase in weight may be necessary to stiffen the structure near the notch, this can be offset against the fact that the aerial contributes nothing to the aerodynamic drag.

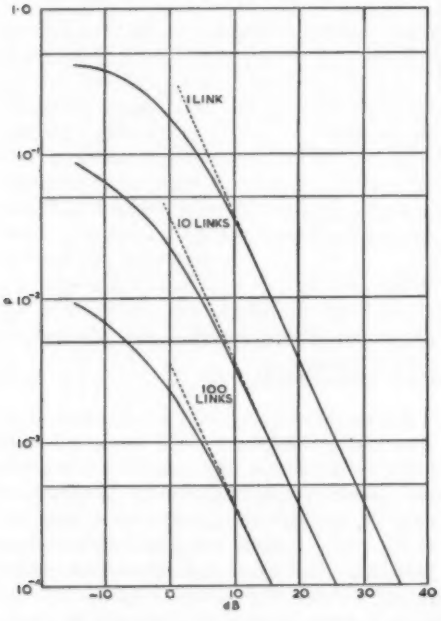
Noise in Transmission Links

A DIGEST OF A RADIO SECTION PAPER (No. 1776) ENTITLED "SIGNAL/NOISE RATIO IN PULSE CODE MODULATION," BY N. L. YATES-FISH, M.A., D.PHIL., AND E. FITCH, B.SC. THE FULL PAPER WAS PUBLISHED IN MARCH, 1955, IN PART B OF THE PROCEEDINGS.

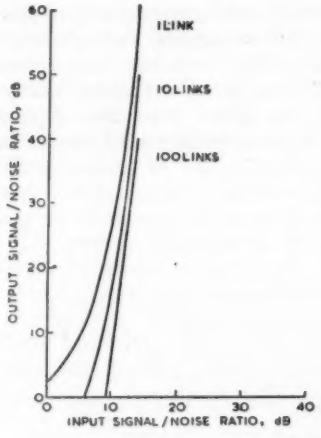
IN PULSE CODE MODULATION successive samples of the modulation waveform are transmitted in digital form as groups of binary pulses. It has been claimed that by the use of pulse regeneration such a signal can be received completely free of noise contributed by the transmission path, and can be relayed over any number of links without deterioration. However, the inevitable random noise in the transmission path will always lead to some finite probability that a pulse will be incorrectly received, and in a relay chain using regenerative repeaters each successive link will introduce additional errors. These errors produce an impulsive type of noise in the output. The power in this noise is almost independent of the number of digits in the code. For a simple pulse code modulation system having uniform spacing of the quantizing levels and passing a modulation band equal to half the sampling frequency, the output signal/noise ratio for a tone producing full modulation is given by the full line curves in Fig. 1 in terms of p, the probability of an error in a single link.

If the pulses at the input of a pulse regenerator have amplitudes $\pm V$ and are accompanied by Gaussian noise of r.m.s. value n_0, the probability of an error, and hence the output signal/noise ratio, can be calculated in terms of the input signal/noise power ratio V^2/n_0. Results are shown in Fig. 2. The output signal/noise ratio falls with increase in the number of links in the same way as for amplitude or frequency modulation; however, owing to the very great slope of the curves, it can be restored by making only a very small increase in the power of each link.

Quantizing noise, which has been ignored here, sets an upper limit to the attainable signal/noise ratio.



1 *Variation of signal/noise ratio with* p *for systems of 1, 10 and 100 links*



2 *Variation of output signal/noise ratio with input signal/noise ratio*

HOME EVENTS

LONDON

ORDINARY MEETING

At the Ordinary Meeting on the 3rd March, 1955, Mr. G. L. E. Metz read his paper entitled "The Electrical Engineering Industry in the Post-War Economy—II." There was a rather poor attendance at this meeting, with a notable absence of younger members; this is to be regretted, for the subject not only closely affects a large proportion of the membership, but is also of paramount importance to Great Britain as a nation. Mr. Metz gave a skilful introduction to the main points of his paper, which follows up an earlier Institution paper written by him in conjunction with Mr. R. L. Davies in 1946. He stressed the cardinal importance to Britain of exports, and pointed out that although the ratio of exports to imports in the electrical industry was very satisfactory, too large a proportion of the goods was exported to sterling countries. The discussion was admirably opened by Colonel B. H. Leeson, who, while praising the purpose of the author and agreeing with much that he had written, would not accept that all his contentions were applicable to the electrical industry in particular, as against Great Britain's industry as a whole; for example, it was not generally true that the electrical industry was slow in applying the fruits of scientific research, and the impending nuclear-energy programme involved research and development on an unprecedented scale. He concurred with the author that "increased productivity" was not the only solution to Britain's import-export difficulties. "It all comes down to more efficiency and, to put it bluntly, harder and longer work."

The President himself took part in the discussion from the chair, and in proposing a vote of thanks to Mr. Metz at the close of the meeting, he stressed the necessity of going out and looking for export business and providing what the customer wanted, not necessarily what was ready on the shelf.

An article based on Mr. Metz's paper will appear in a future issue.

EXTRA MEETING

Leave Well Alone

Mr. R. W. Palmer presented his paper on *Maintenance Principles for Automatic Telephone Exchange Plant* at an Extra Meeting held on the 10th February, 1955, which was attended largely by engineers from all the automatic-exchange-equipment manufacturers and from the Post Office. A digest of the paper appears on page 229. He emphasized that maintenance technique which is best for one kind of engineering plant is not necessarily best for all, and illustrated the point by the example that the high proportion of preventive maintenance essential for an oil lamp would do more harm than good if applied to an electric filament lamp. Again, the failure of 1% of a system of street lamps may be of little consequence, yet some measure of routine inspection and maintenance may be necessary to ensure that the percentage of failures does not rise too high. For such reasons any review of telephone-exchange maintenance must be qualified by the quite large differences in types of plant.

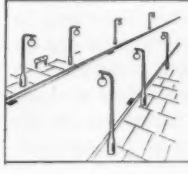
The majority of the world's automatic-exchange plant is of the step-by-step type, and the maintenance appropriate to that system is not necessarily suitable for power-driven or cross-bar systems; again, it would probably be unwise to apply the same technique to an electronic exchange when such is developed.

In terms of service failure, maintenance effort must be distributed over three functions (see Fig. 4 of the digest):

(i) Prevention of service failure (including prevention of plant faults),
(ii) Disclosure and location of service failure, and
(iii) Correction of service failure (or of plant faults).

Maintenance policy must decide whether the maintenance effort is to be directed to preventive maintenance by routine functional testing and routine overhauls, or by qualitative maintenance as now adopted in the United States, where the work performed is varied locally

Typical composition of total maintenance effort according to class of plant

CLASS OF PLANT	COMPOSITION OF TOTAL MAINTENANCE EFFORT		
	ROUTINE PREVENTION OF FAULTS	TEST AND INSPECTION FOR FAILURE	CORRECTION OF FAULTS
OIL LAMP	95 %	NIL	5 %
ELECTRIC FILAMENT LAMP	5 %	NIL	95 %
 COMPLETE INSTALLATION OF ELECTRIC STREET LAMPS	5 %	90 %	5 %

according to the current state of individual items of plant.

Mr. D. A. Barron, who opened the discussion, said that both the United States and Great Britain initially followed, for Strowger equipment, the same maintenance policy of routine attention at prescribed intervals. In 1938, after an extensive experiment at Bristol, an instruction was issued that the periodicity of routine maintenance attention should be adjusted to meet proven necessities. After the Second World War, field experiments were continued, and, as a result of the evidence obtained, the nominal intervals of maintenance attention to some items of equipment are now three times longer than before the war. Further, local controlling officers continue to have full discretion to vary these intervals in accordance with the particular needs of different installations. In 1948 the American Telephone and Telegraph Co. similarly began a re-examination of their early practice, and subsequently decided that maintenance should be on a qualitative basis. He thought that the basic similarity of the conclusions reached as a result of independent investigations in the two countries was very striking.

Mr. W. H. Grinsted said that fault statistics gave no information regarding failures due to unreliability in apparatus design and failures due to too small margins in circuit design. Such information would be invaluable to the manufacturer. The author's definition of a fault, namely "an imperfection of plant or of service requiring attention as part of the maintenance function," did not find favour with Mr. T. P. Priest, since this definition left it to the maintenance staff to decide whether an imperfection was a fault. He preferred "a fault is any defect which prevents any equipment, etc., fulfilling the function for which it was provided." He said that experience oversea shows that overhauls do more harm than good unless they are carried out by skilled staff properly trained and well supervised. Moreover, support for Mr. Priest's definition of "fault" came from Col. C. E. Calveley, who quoted figures obtained in the circuit laboratory of the Post Office, where a selector in "faulty" adjustment (i.e. outside the prescribed limits), performed 300 000 operations. He wondered whether, in a few years' time, the Americans might decide it was wrong to have expensive engineers sitting on chairs analysing faults instead of paying attention to the equipment on the floor of the exchange.

Mr. N. C. Smart suggested that the present equipment as supplied to the Post Office was often too good for the job and quoted that on life test the present standard subscribers' uniselector gave two million calls (at 50 calls per week, a life of 800 years).

Other speakers all supported the author's suggestion that maintenance effort should be directed according to the state of individual items of plant and should not be on a basis of a rigid routine. The author replied to the points raised in the discussion, and ably defended his choice of title on the grounds that the paper was on the principles of maintenance and not solely on the practice.

The Chairman, Sir Gordon Radley, said that the present instructions in the Post Office gave freedom and responsibility to the local staff for deciding where to direct their maintenance effort, and in this respect the American and British directives were similar. He felt that the keynote of the paper and the discussion supported the adage "Leave well alone." In complimenting the author, who had studied maintenance practice in the United Kingdom, the United States and Sweden, on the valuable paper which had been presented, he expressed the views of all present. J. R.

MEASUREMENTS SECTION

The attendance was above average at the meeting on the 1st February, 1955, at which two papers, by Mr. D. Edmundson and Mr. A. Hobson, were presented.

In his introduction to the paper *Electrical and Magnetic Measurements in an Electrical Engineering Factory*, Mr. Edmundson stated that one of his objects was to record trends and developments in specialist instrumentation embodying electronics. He claimed that the use of negative-feedback amplifiers in power and voltage measurements simplified many problems where instrument burdens would otherwise be a nuisance. Numerous examples were explained by the help of lantern slides, many of which were coloured.

Demonstrations of the slip-frequency meter and dynamic hysteresis-loop tester were very effective. It was rather fascinating to watch the shape of the oscillograph curves change as the controls were manipulated, while the sensitivity of the slip-frequency meter could be appreciated on realizing that the instrument gave readable deflections if the search coil were oscillated by hand in the earth's field. A digest of the paper appears on page 228.

Mr. Hobson, in presenting his paper on *Current Summations with Current Transformers* referred to suspicions regarding the accuracy of summating parallel circuits owing to the supposed effect of idle feeders. He went on to describe conditions existing when a number of current-transformer secondaries are paralleled to a common burden. The voltage across the burden is the same irrespective of how the total load current is divided, and the combination behaves as a single measuring device with equivalent error. Similar reasoning also applies to a summation transformer. A significant fact is that the actual position of the parallel connection is unimportant, but it is necessary that the line transformers shall have the same percentage of turns compensation, if any. Actual test results were quoted to demonstrate the accuracy of the theories advanced. A digest of the paper appears on page 231.

The discussion was lively and varied, the weight falling on Mr. Edmundson's paper with its large scope in the field of measurement. It was opened by Professor J. Greig, who said that the arguments of Mr. Hobson's paper were delightfully simple and above all worked in

practice. He was also very interested in Mr. Edmundson's use of negative-feedback amplifiers, citing his own experience of their use in flux measurements and asking the author whether he had applied them to maintain waveform in magnetic measurements; the efficacy of the polarized-relay technique in iron testing was confirmed, and the author was asked for possible experience with the device in the measurement of acceleration.

Dr. A. H. M. Arnold struck a cautionary note regarding Mr. Edmundson's statement about the accuracy of the feedback amplifier and his reference to frequencies up to 5 000 c/s. The accuracy might be loosely construed as an overall figure. He also pointed out to Mr. Hobson that the summation transformer suffers in comparison with paralleled transformers owing to the additional burden, but that this is probably outweighed by the practical advantages.

Several speakers referred to the question of diversity in dealing with summation of paralleled circuits, and to the fact that they must always remain in parallel, for otherwise any voltage difference would affect accuracies. Some comments were made on the various methods of magnetic and loss measurements described by Mr. Edmundson; in addition, the polarized-relay technique aroused considerable interest, while the power-factor method received some criticism.

In replying, Mr. Edmundson stated that, although he had not used amplifiers to provide a sine-wave magnetizing current, several of his colleagues had. It was, however, a difficult problem because of distortion. He preferred the high-speed polarized relay to a commutator, because it can be "forced" from one position to the other with great consistency and has been found to be more convenient to use.

Mr. Hobson said in his reply that the main object of his paper was to lay an old bogey regarding summation. He was greatly indebted for the many comments, which in the main supported his contention.

In moving a vote of thanks to the authors, the Chairman, Mr. M. Whitehead, stressed the usefulness of electronics in the field of measurement. C. R.

RADIO SECTION

Reliable Valves

A paper on *Thermionic Valves of Improved Quality for Government and Industrial Purposes* by Mr. E. G. Rowe, Mr. P. Welch and Mr. W. W. Wright was read on 12th January, 1955, before a large and appreciative audience. The audience, in fact, numbered 278, and its size indicates the wide interest taken in the subject of "reliable" valves. The authors had wisely chosen a title which would attract all users of valves.

The paper, presented by Mr. E. G. Rowe, describes work done by the authors and their colleagues in studying valve reliability requirements, causes of valve failure, and applying test conditions which are capable of reproducing field failures. The types of valves covered by the work are the general-purpose valves, not those designed for special applications where severe conditions are imposed —as, for example, valves for use in projectiles. The authors emphasized that, whilst their work had progressed most satisfactorily in helping to produce a new range of valves, it was nevertheless quite wrong to deduce from this that ordinary commercial valves were not reliable.

In addition to the data in their paper showing the improvements resulting from this work, the authors took the opportunity of indicating that a tremendous effort is being made by the valve industry and the Government establishments, and that a similar exercise seems to be needed on related components if general equipment reliability is to be achieved. Mr. Rowe, in concluding his presentation of the paper, appealed for the co-operation of all circuit and equipment designers in furthering this.

A very lively and instructive discussion followed, contributions coming from Service users, industrial users and the valve industry. Dr. J. Thomson, opening the discussion, enumerated the requirements for the manufacture of reliable valves and stated that valves can be considered reliable only in a defined way. He estimated that a production run of the order of one million valves is required for a valve to be classed as reliable, and he too appealed to circuit engineers to co-operate in using valves to gain more confidence.

Dr. G. H. Metson indicated the studies he considered should be pursued to further the cause of reliable valves. He asserted that long life and high performance are not incompatible and placed emphasis on the properties of materials used, particularly for cathodes.

A valuable contribution to the discussion was made by Air Marshal Sir R. Owen Jones, who is Controller of Engineering and Equipment in the R.A.F. He congratulated the authors and valve industry on a most valuable advance in reliability of valves in service operation. The valve had been formerly the most unreliable component in an aircraft; tests done under strict control now showed that this was no longer so. Mr. R. H. Colcutt of the R.A.F. Scientific Service gave figures supporting these remarks.

The question of wired-in valves instead of socket-held valves was commented upon by Mr. F. M. Walker, who did not agree with the authors in advocating that all valves should be wired-in. Valve sockets were criticized and this caused some amusement when a little later in the discussion a member—himself a manufacturer of valve sockets—replied to this criticism. He pointed out that sockets as well as valves were made to very close specifications. Mr. K. Hopkinson gave an account of the work done in drawing up satisfactory specifications for valves of this class and establishing the right test conditions. Mr. H. R. Reid regretted that the paper did not cover other types of valves and queried whether enough attention was being paid to new processes of manufacture.

A number of other members spoke, leaving little time

for the reply, in which each of the three authors helped to wind up a most profitable discussion. L. R.

From Sunspots to Scotch

It is the aim of the radiocommunication engineer to maintain a continuous service over all the circuits for which he may be responsible: it is also his sad experience that there are times when this appears to be impossible. On February 9th two papers concerned with aspects of the performance of long-distance h.f. radio circuits were read before a meeting of the Radio Section: *A Study of Commercial Time Lost on Transatlantic Radio Circuits due to Disturbed Ionospheric Conditions* by Mr. J. K. S. Jowett and Mr. G. O. Evans; and *Performance Characteristics of High-Frequency Radiotelegraph Circuits* by Mr. A. M. Humby, Mr. C. M. Minnis and Mr. R. J. Hitchcock. Digests of these papers appear on pages 236 and 234. From the lively and instructive discussion these papers produced it was evident that they aroused much interest among the audience.

The two papers were introduced by Mr. Humby and Mr. Jowett respectively: the latter ended his remarks in humorous vein, saying that it appeared possible to correlate the cycle of sunspot activity with almost anything. He cited, by way of example, the periodic occurrence of "booms," "hard times" and "panics"—as seen through the eyes of the whisky distiller.

The discussion on the two papers was opened by Mr. F. Axon, who said that the present time was an appropriate one for the papers to appear; we are entering a new solar cycle (following the recent minimum of activity)—rather like starting a radio "New Year"—and we have the chance of trying to plan for the better use of the radio-frequency spectrum: the material in the papers should help in this task. Mr. G. Millington spoke next, and drew attention to the fact that much could be learnt from the transmission characteristics of long links which it was not yet possible to deduce from vertical-incidence (at the ionosphere) and short-range measurements. He thought that the authors' results, since they were not based on actual field-strength determinations, were not definite proof of non-reciprocity of propagation over the circuits examined. This matter was also touched upon by other speakers, including Mr. H. Stanesby, who said that carefully controlled tests on circuits from the United Kingdom to the United States and Australia had indicated that reciprocal transmission obtains on a long-term average, although the day-to-day performance in this respect is at times variable.

Mr. A. F. Wilkins remarked that during the past 30 years much information must have been obtained by operating engineers which it would be valuable to study from a fundamental aspect, a point later reinforced by Dr. R. L. Smith-Rose, who hoped that the present papers would be succeeded by similar ones from time to time. Dr. Smith-Rose also said that, so far as it was possible, the results of such investigations should be expressed in a uniform manner—and perhaps it would be better to talk about the efficiency of a circuit rather than the amount of time lost on it. Mr. J. A. Smale thought that the greatest communication difficulties occurred around the hour of 7.30 a.m. at the equinoxes, and not at night in winter as suggested by Mr. Jowett: he went on to illustrate the improvement in circuit efficiency which could be obtained by the use of relays. This point was also made by Mr. H. Leigh in connection with the London–New-York circuit; in this the introduction of a relay at Barbados (so getting away from the auroral zone) had materially increased the useful commercial time on the circuit.

In reply to the discussion Mr. Minnis said that he and his co-authors had, when considering diurnal variations of circuit performance, confined their attention to correlation with ionospheric characteristics. However, he thought it might be worth while to investigate the possibility of correlation with diurnal magnetic variations as suggested by Mr. Finch; but a difficulty in pursuing this matter is that the effects on transmission of a magnetic disturbance depend vitally on the value of the operating frequency in relation to the lowest and maximum usable frequencies. On the question of reciprocity Mr. Minnis emphasized that the authors had deliberately used the term "asymmetry," because they did not wish to imply necessarily the existence of non-reciprocity; factors other than propagation affect the issue. Mr. Evans, in his reply to the discussion, said he thought that two frequencies should be sufficient allocation for a given circuit. The performance of circuits had been correlated in their investigation with magnetic activity rather than with an ionospheric index, as Mr. Wilkins had suggested should be done, because (for transatlantic circuits) correlation with ionospheric soundings near the ends of the circuits had not proved very profitable. J. A. S.

SUPPLY SECTION

A Fine Lecture

In the post-war years the notable developments in high-voltage transmission and power in Sweden have been consistently in the news and always associated with the name of Mr. Åke Rusck. It is not surprising, therefore, that the evening of the 23rd February, 1955, found the theatre of The Institution filled practically to capacity for the Annual Lecture of the Supply Section, which Mr. Rusck had been invited to deliver. He had chosen as the title of his lecture *High-Voltage Transmission Developments in Sweden.*

Mr. Rusck introduced himself charmingly to his audience by referring to the work of the British pioneers in electrical engineering, and he continued by saying that, in travelling over from Sweden by air, he had been reading the recent report of the British Government on *A Programme for Nuclear Power.* In reading this report he had come to realize how small were the electrical problems of Sweden with its population of about seven million people compared with those of Great Britain;

and this had made him wonder indeed what there was that he could tell to a British audience. "However," added Mr. Rusck, "I have made my promise, so that I must do the best I can with the lecture I have prepared."

Mr. Rusck's fears were unfounded, since he had much to tell which was of the highest technical interest. He described the general conditions in Sweden, with its absence of native fuel, a preponderance of hydro-power in the north and a preponderance of industrial consumption in the south. These had led to the project to harness the hydro-power at Harspranget, which is inside the Arctic circle, and to transmit the power a distance of 600 miles to the neighbourhood of Stockholm.

Mr. Rusck described the planning and development work for the various types of equipment required for the transmission of power at 380kV over such a long distance. This work included the design of the series capacitors for voltage regulation, the successful use of which on a 380kV line was a notable Swedish development. He described also the development work that is at present in progress for transmission lines of 650kV, which are now being contemplated.

Mr. Rusck then turned to the second part of his lecture, dealing with the Gottland project for the submarine transmission of power at 100kV d.c. over a distance of 60 miles. Again, after explaining the particular conditions calling for such a project, he described the development and final construction of the various pieces of equipment, particularly the 100kV d.c. submarine cable, in the course of which he paid tribute to the work of the British Post Office cable ship *Alert*. His British audience were, perhaps, especially interested in the successful operation of the sea path for the return current, in view of the controversy about this in connection with the proposed cross-Channel cable. The method is apparently working in Sweden to the satisfaction of the electrical engineers, and no ships have lost their way, or been wrecked.

After the lecture a film was shown which described the whole of the Gottland project in great detail. This was the first public showing of this film and had been organized to take place simultaneously in London and in Sweden. The film was of the highest technical interest, but was somewhat marred by uneven running of the projector, especially towards its end. It is understood that such trouble may sometimes arise when an entirely new film is projected for the first time. However, the information conveyed by the film was in no way impaired.

After the lecture a vote of thanks was proposed by Dr. L. G. Brazier. He referred to the keen interest in Great Britain that had been taken in these notable and valuable electrical developments in Sweden. As a cable maker he drew attention specially to the considerable achievement of using cable connecting links designed for operation at 380kV. He recalled that Mr. Rusck had been appointed President of the Swedish State Power Board in 1948, i.e. 14 years after graduating at the Stockholm Technical University. In the circumstances it was not surprising that Mr. Rusck had been regarded as an outstanding student in his years at college. Dr. Brazier said that Mr. Rusck had been awarded the honour of Commander First Class of the Royal Order of the North Star, and he felt that this was a particularly felicitous decoration for an engineer who had brought power and light from inside the Arctic Circle.

Mr. D. P. Sayers, in seconding the proposal, recalled a visit to Sweden in 1951 to see the construction of the 380kV line which was then under way. Perhaps his chief impression was the overwhelming hospitality of the Swedes. He said that this was only Mr. Rusck's second visit to England, and he remembered the compliment that Mr. Rusck had paid to The Institution when 12 months ago he had visited it for the purpose of joining in the discussion on the paper on the cross-Channel cable. He paid tribute to the technical enterprise and pioneer work which had enabled these developments in Sweden to be carried out.

The meeting enthusiastically acclaimed the vote of thanks for an Annual Lecture which was undoubtedly of the highest possible standing and interest. L. G. B.

UTILIZATION SECTION

Fuse or Circuit-Breaker?

At the meeting on the 20th January, 1955, Mr. H. W. Wolff and Mr. T. G. F. Atherton presented their paper entitled *Design, Performance and Application of Miniature Circuit-Breakers*. They pointed out that overload and short-circuit protection have in the past been effected principally by fuses and circuit-breakers, both of which have their limitations. Consequently there is the need for some protective device embodying the main advantages of each, and this has led to the development of the miniature circuit-breaker, which is an attempt to combine the small size and cheapness of a fuse with the dependability and re-switching feature of the circuit-breaker.

An outline of the historical development of miniature circuit-breakers was given, and this was followed by an indication of the many requirements which have to be met, together with a study of the more important design features. The authors also compared the application and economy of these circuit-breakers with other forms of protective gear and made some suggestions for their future development.

One can be fairly certain that if a statement is made in public about the earliest recorded use of a particular type of apparatus, there will be someone ready to produce evidence of an even earlier date. Accordingly, it was not surprising that, although the authors had asserted that miniature circuit-breakers were first designed about 1910, a speaker should declare that he knew of one that was in existence in 1905. Quite a number of contributions were made to the discussion, which centred mainly around the relative merits of fuses, miniature circuit-breakers and a combination of both. Reference was

also made to the ability of the miniature circuit-breaker to combine overload, short-circuit, shock- and fire-risk protection, and facility for remote indication, all in one relatively small unit.

As regards its field of application, although one speaker waxed quite lyrical by saying that "there were lots of fields to be tilled and the harvest would be marvellous," the general view was that it could not compete economically with the fuse in domestic premises, but that there were many industrial and commercial installations where the initial cost might easily be recoverable in a short period by the saving of maintenance and delay charges.

It surely was an optimist who expressed the view that the whole of the problems associated with discrimination would be solved if any manufacturer could develop a breaker with oil-circuit-breaker performance at a miniature-circuit-breaker price. A good point was made by the final speaker, in which he regretted that so little had been said about the d.c. applications, and cited, in particular, road and rail traction and marine installations.

Altogether it was a rather informative and lively discussion.

Three Students' Papers

At the meeting on February 17th three short papers were read by Students. This was in continuance of the Utilization Section's customary practice of devoting one meeting each session specially to this purpose.

The first paper (which had gained a Student's Premium) was entitled *An Introduction to the Study of Servo Mechanisms*, and was read by Mr. P. J. Bhatt. In his introductory remarks the author defined a servo mechanism as an automatic self-operated system that regulated an output quantity. The operation of several typical systems was described, and then the subject was developed mathematically to cover elaborate instances of their use.

This was followed by the paper by Mr. E. J. Davies, which was on *The Development of 50c/s Traction in France*. In this paper the author argues the case for railway electrification using power-frequency alternating current.

Finally, Mr. G. Gascoigne read his paper entitled *Electricity applied to Oil Production*. This included some interesting details of the application of electricity to the various forms of pumping machinery employed in oil fields, a subject with which it is fair to say the average electrical engineer is very little acquainted.

At the end of each paper a discussion took place, and the relevant author had the opportunity of replying to the various points raised. The standard of all three papers was excellent, and the fact that the meeting was very well attended was ample proof that the senior members of the Section fully endorsed the Section Committee's contention that meetings of this character are well worth while encouraging.

Annual Dinner-Dance

The third Annual Dinner-Dance of the Utilization Section was held at the Café Royal on Wednesday, January 19th. A total of 145 members and their ladies were present and the evening proved very enjoyable. Members of the Section were pleased to welcome among their guests the President and Mrs. Eccles, the Chairman of the Measurements Section and Mrs. Whitehead and the Chairman of the Supply Section and Mrs. Peattie.

R. H. R.

BELFAST

NORTHERN IRELAND CENTRE

Teleprinting at Speed

The 1954–55 session opened with an Address by the incoming Chairman, Major P. L. Barker, preceded by the presentation to the retiring Chairman, Mr. J. R. W. Murland, of the Certificate of Chairmanship, and by the moving of a vote of thanks to him for the excellent work he had done on behalf of the Centre during his term of office.

In his address Major Barker described three important developments in telecommunication engineering which had been introduced into Northern Ireland during the past few years. He included a general description of the coaxial-cable system between Belfast and Dublin, and explained the principles of the automatic-teleprinter-switching system whereby teleprinter stations can establish connection with each other by dialling. A temporary station was set up in Queen's University for the occasion, and a demonstration of teleprinter communication with two stations in Great Britain was given. Even assuming that the Post Office was in "high gear" at the time, the replies came back at phenomenal speed. Finally, Major Barker described the Post Office link for the temporary television station at Belfast, the receiving station on the summit of the Black Mountain for the direct reception of the signals transmitted from Kirk o'Shotts, and the coaxial-cable link between receiver and local television transmitter.

Ethics in Uganda

The second meeting of the session was a joint meeting with The Institution of Civil Engineers, the subject being the Owen Falls project in Uganda. Sir Charles Westlake and Mr. T. A. L. Paton crossed to Northern Ireland to present the paper. The large Zoology Lecture Theatre at Queen's University was packed, for the subject was of considerable interest to both civil and electrical engineers, and, in addition, Sir Charles is well known in Ireland for his work in the establishment of the Electricity Board for Northern Ireland.

As might have been expected, the subject was dealt with in an authoritative and entertaining fashion by its authors; but the discussion which followed was unexpectedly lively and, in its own way, nearly as interesting as the paper. Professor Naylor opened for the civil engineers and, since he had surveyed the ground in 1935,

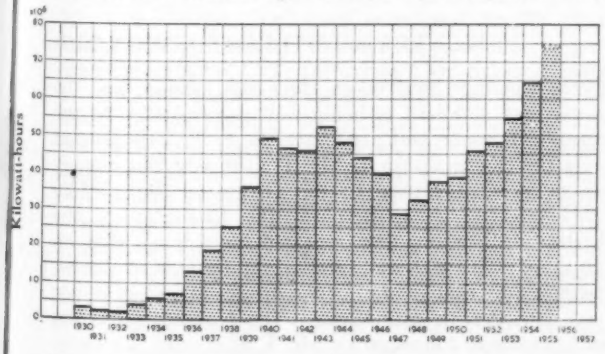
he was well acquainted with Uganda and its problems. He was frankly pessimistic about the site chosen for the dam, and more especially, about the impact of such a scheme on the peasant people of Uganda. A large part of the ensuing discussion showed the concern which the contributors felt about the ethics of building a large power station in a country which had been previously undeveloped industrially. So much reference was made to the sociological and moral aspects of electrifying Uganda, indeed, that a visiting civil engineer from Britain felt constrained to remind the speakers (mainly electrical engineers) of the terms of the Charter of The Institution of Civil Engineers. This effectively quenched further discussion. Sir Charles and Mr. Paton maintained their imperturbability throughout and emerged with credit from what must have been an unnerving experience.

Talking off the Point

At the December meeting Mr. F. J. Lane presented the paper on *The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems* by Monsieur M. E. Laborde, Mr. D. P. Sayers and himself. The meeting was again held jointly with The Institution of Civil Engineers. Although the lecturer in no way underrated the difficulties of such a project, his dispassionate presentation of the pros and cons convinced his listeners that it was technically and economically feasible. The excellent film illustrating the laying, jointing and testing of specimen lengths of cable showed vividly some of the technical difficulties encountered. The discussion which followed ranged from the virtues of d.c. transmission to the possibility of building future power stations for Ulster in Scotland, together with some reminiscences about underwater cables already laid across Larne Lough and elsewhere in Northern Ireland. Mr. Lane may have been slightly bewildered by the twists and turns of the discussion, but he answered all the questions put to him with unfailing good humour.

In January an informal paper by Mr. J. R. W. Murland and Mr. R. L. Marrs on *Control and Protective Circuits for Small Self-Exciting Induction Generators* completed the first half of the session. Realizing the propensity of members for wandering from the main theme in the discussion, Mr. Murland reminded all prospective contributors that the paper referred to control and protection and not to the generators themselves. During the subsequent discussion it was evident, from the wistful note in many a speaker's voice, that those generators were not without interest.

This local paper gave the members an insight into a previously unsuspected part of Northern Ireland's electrical development, three working schemes being described and their economics justified. D. S. M.



Electrical energy consumption of the Bristol Aeroplane Co.

BRISTOL AND CARDIFF

WESTERN CENTRE

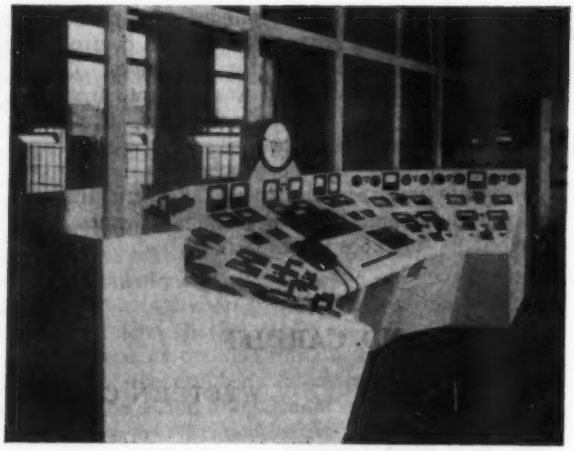
From 100 to 40 000 kilowatts

A crowded meeting at Bristol on the 4th October, 1954, gave the new session an excellent start. Mr. J. Vaughan Harries said that he was greatly pleased to place his successor, Mr. A. N. Irens, in the chair, but it was just as well that he did not have to do so physically!

Mr. Irens then gave his Chairman's Address, which took the form of a review of the development of the power supply system of the Bristol Aeroplane Co. from 1910 (the era of the famous "Box Kite") to 1954, the era of the Bristol Britannia and the helicopter. The address was well illustrated with lantern slides and proved to be one of the most interesting to local members of those given in recent years. It has not been published in the *Proceedings*, and there follow here a few extracts from it.

Aircraft manufacture was started in 1910 by the British and Colonial Aeroplane Co., which was an offshoot of the Bristol Tramways Co. The electricity requirements of the factory, such as they were, were provided by a tapping at 500 volts d.c. from a tramway pole at the extremity of the system. As one might expect, this was not very satisfactory owing to the wide fluctuations in voltage, and a special single-core cable was therefore laid alongside the track for a distance of 4½ miles to the tramway generating station, the earth-return system being used. In order to maintain voltage at the factory, a rotary booster was installed at the power station; this raised the voltage by about one volt for every ampere of load, giving a cable potential of up to 700 volts, with a total load of about 100 kW. During the First World War, six 100 kW twin-cylinder horizontal gas engines were installed, using coal or wood waste from the aircraft as fuel for the gas plant.

In 1925 the first high-voltage supply was brought in from the public authority, and the capacity has been progressively increased over the years to the stage where there are now eight incoming 11 kV cables, making available from the Electricity Board about 40 000 kW. In addition to this, there are now nine high-speed Diesel generators rated at just over 1 000 kW each and connected to the 11 kV system, which were installed mainly as a



Central load-control in the works of the Bristol Aeroplane Co.

result of the 1947 power crisis. They are used for peak-load generation and as an emergency standby.

The manufacture and development of reciprocating engines called for a number of large variable-speed motors for cooling fans, supercharger testing and other purposes. For this reason the original 500-volt d.c. system was extended to have a capacity of 17 000 kW, mostly by the use of rotary convertors. With the change-over to turbine engines, d.c. requirements have fallen off, and this fact, coupled with the tendency to have individual motor drives on machine tools, has resulted in a worsening of system power-factor. As a result it has been necessary to install power-factor correction capacitors, which provide over 6 000 kVAr. The control of the capacitors is partly automatic, and partly manual by the load control operator, who also calls up generating plant as required.

Cross-Channel and Transatlantic

The December meeting of the Centre is usually one which appeals also to the Specialized Groups. There was a good muster, therefore, on the 13th December, 1954, when Mr. Irens was supported on the platform by Mr. T. Gill, Utilization Group Chairman and Mr. E. Hywell Jones, Supply Group Chairman. At this meeting the Centre welcomed Mr. Brasher; in a short and pithy speech he appealed to all members to do everything in their power to make good the shortage of young men entering the electrical engineering profession. Mr. D. P. Sayers then presented the paper on *The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems* by Monsieur M. E. Laborde, Mr. F. J. Lane and himself. Mr. W. Hill opened the discussion by relating his experience with cables across the Severn estuary over a period of 30 years. Ten other speakers took part, and an excellent evening closed with a vote of thanks ably proposed by Mr. A. C. Thirtle.

At Cardiff on the 3rd January, 1955, Mr. F. H. S. Brown read his paper on *Some Design Features of the Semi-Outdoor Power Station at Ince*. A good discussion was opened by Mr. C. W. Priest and many interesting points regarding both construction and operation were raised. A vote of thanks was proposed by Mr. W. A. Gallon. On January 17th a joint meeting with the Institution of Post Office Electrical Engineers was held at Bristol, when Sir Gordon Radley read the paper on *A Transatlantic Telephone Cable*, written by Dr. M. J. Kelly, Mr. G. W. Gilman, Mr. R. J. Halsey and himself. The attendance and discussion amply justified the action of the Committee in arranging this extra meeting.

WESTERN SUPPLY GROUP

Over 50 members of the Group and their ladies visited the Blackwood works of the South Wales Switchgear Co. on the 2nd October, 1954, when they were received by the Managing Director, Mr. A. J. Nicholas, who is a local member. After a most interesting tour of the works they were entertained to lunch, and in the afternoon there was a trip to the Usk Valley and neighbouring countryside, which, as the outing last year, was favoured with good weather.

At the opening meeting of the session at Cardiff, Mr. L. F. M. Baker handed over the chair to Mr. E. Hywel Jones, who addressed the meeting on various operational problems of a Generation Division. His talk was illustrated by films which were well received.

On the 10th January, 1955, informal papers on industrial supply were given from three viewpoints—Mr. R. H. Cobbold as consumer, Mr. W. P. Warren as commercial engineer, and Mr. J. S. Lombard as distribution engineer. There was an excellent attendance at this Cardiff meeting, but the discussion was hardly as brisk as one might have expected. Perhaps too many speakers concentrated on tariffs—not the lightest of subjects. Again, there was so much good sense in what Mr. Cobbold, Mr. Warren and Mr. Lombard had to say that the wordy warfare in which Cardiff meetings can engage never developed. Mr. Beckingsale (from Bristol) made the briefest and brightest contribution to the discussion.

WESTERN UTILIZATION GROUP

Three meetings have taken place this session, and the usual high standard is being well maintained. At the opening meeting at Cardiff Mr. F. P. Phillips handed over the chairmanship to Mr. T. Gill, who has already given excellent service to the Group as Secretary in 1945–48. Mr J. I. Bernard, the Chairman of the Utilization Section, then repeated his Address given in London. This was well received, and a vote of thanks, proposed by that veteran of the group, Mr. C. T. Allen, was carried with enthusiasm. The November meeting in Bristol was addressed by Mr. J. M. Druce, who gave an informal lecture on *Electrical Planning for a Modern*

Cigarette Factory. As was to be expected in the home town of the cigarette, the minutes record that "a lengthy discussion took place." Points raised were dealt with by the lecturer and by Mr. R. H. Cobbold; Mr. W. H. Small proposed the vote of thanks. On the 24th January, 1955, Mr. P. R. Grey presented the paper *Safety in the Use of Portable and Transportable Equipment in Industry* in the unavoidable absence of its author, Mr. J. W. Bunting. Mr. C. E. Dew opened what proved to be an animated discussion, and many important matters concerning safety were brought to light. Mr. Roper proposed the vote of thanks. B. C. R.

BURTON-ON-TRENT

DISTRICT MEETING

An Enthusiastic Town

The North Staffordshire Sub-Centre held its first District Meeting at Burton-on-Trent on the 1st March, 1955. The paper chosen was Mr. E. C. Rippon's *Design and Constructional Features of a 275kV Special-Duty Transformer Bank*, which was read by his colleague Mr. R. Bruce. An unexpectedly large gathering of 65 members and guests (no beer was served), including a healthy proportion of Students, heard a very lucid description of this unusual transformer bank. The discussion was pleasantly informal yet demonstrated keen interest in the subject.

It was obvious that the choice of Burton-on-Trent for a District Meeting was a good one, and this was emphasized by several requests for further meetings in the near future. Credit is due to the convener, Mr. F. Overstall, for all his efforts, which resulted in such success. L. G.

EDINBURGH, INVERNESS AND GALASHIELS

SCOTTISH CENTRE

On the 4th March, 1955, a record number (about 175) of members and guests assembled at the Caledonian Hotel for the Edinburgh Dinner, under the Chairmanship of Mr. J. S. Hastie. The chief guest was the Rt. Hon. James Stuart, Secretary of State for Scotland; in proposing the toast of "The Institution" Mr. Stuart referred to the new South of Scotland Electricity Board, for which he was shortly to assume responsibility. He foresaw a good start for the Board based on the sound work of the existing organizations in South Scotland, and on the experience gained in 11 years' successful operation of the North of Scotland Hydro-Electric Board. In replying, the President wished the new Board well and promised the utmost co-operation; Mr. Eccles also appealed for greater opportunities for the study of science in the schools and wider curricula in technical colleges. The toast of "Our Guests," proposed by Mr. E. O. Taylor, Chairman of the South-East Scotland Sub-Centre, was replied to by Brigadier K. G. Legh-Winter, R.E.M.E., who commented on the employment of engineers in the army. The Centre was pleased to welcome Mr. Brasher, who, on being invited to speak, recounted his dealings with the Lord Lyon King of Arms and explained the difference between the Institution Coat of Arms for Scotland and that which is exhibited in London. A most enjoyable evening then terminated with a toast to the Chairman proposed by Mr. W. B. Laing, Senior Vice-Chairman of the South-East Scotland Sub-Centre.

The South-East Scotland Sub-Centre was recently honoured by its first Vice-Presidential visit, when Mr. T. E. Goldup attended meetings of both the Sub-Centre and the Students' Section. At the Sub-Centre meeting on the 15th February, 1955, Mr. J. S. Hastie, Chairman of the Scottish Centre, read an informal paper on *High-Voltage Cables*. Mr. Hastie traced the development of cables from Ferranti's 10kV Deptford cable to the 380kV cables at Harspranget in Sweden; the temporary setbacks resulting from the attempted operation of belted cables at 33kV and of solid cables at 66kV were described in detail, together with the remedies which have resulted in the modern oil-filled and gas-pressure types. In proposing a vote of thanks to Mr. Hastie, Mr. Goldup referred to the informality and atmosphere of good fellowship that can be achieved in the Local Centres and Sub-Centres.

In February, District Meetings were held by the North Scotland Sub-Centre at Inverness and by the South-East Scotland Sub-Centre at Galashiels; on both occasions Scotland was swept by exceptional snowstorms, which blocked roads and limited the attendances to those living in the immediate neighbourhood. At Inverness on February 15th there was an attendance of 35 to hear an informal paper by Mr. J. E. Whittaker, Chairman of the North Scotland Sub-Centre, on *Natural Sources of Energy*. Mr. McBean took the chair and, as on previous occasions at Inverness, the meeting was most successful. In Galashiels on February 22nd, 38 members and guests assembled to hear Mr. T. H. Carr read the paper by Mr. A. J. Francis and himself on *Electricity in the Wool Textile Industry*; since Galashiels is a world-famous centre of the tweed industry a lively discussion was ensured. The chair was taken by Mr. G. H. Sankey, who, assisted by Mr. D. M. Thornton, had made the admirable arrangements for this first District Meeting in South-East Scotland. E. O. T.

HULL

DISTRICT MEETING

The third District Meeting was held on the 13th January, 1955, with 23 members and guests present and with Mr. W. S. Milner in the Chair. On this occasion Hull members were delighted to welcome the Centre Chairman, Mr. W. A. Crocker, who delivered his Chairman's Address entitled *Management and Men*. This describes

his reactions to the problems associated with the management of an electricity supply Sub-Area. As a gesture to the informality of the occasion, Mr. Crocker was good enough to answer questions, which were put by several members. Mr. Shackleton admirably expressed thanks to the Chairman for his stimulating Address. J. L.

IPSWICH

DISTRICT MEETING

The first District Meeting of 1955 in Ipswich was held on January 4th at the Crown and Anchor Hotel, with Mr. J. R. Rowbottom in the chair. Mr. S. D. Whetman read his paper entitled *Design Factors of Certain British Power Stations* of which he is co-author with Mr. A. E. Powell. The paper dealt with five stations: Blackwall Point, Early, Poole, Littlebrook B and Cliff Quay. The last is naturally of particular interest to local members. The paper dealt with the more important aspects of the design of these stations and was illustrated with lantern slides showing general arrangements of the stations and associated boiler plant. Mr. Whetman answered a variety of questions from the members present. A vote of thanks was proposed by Mr. C. T. Melling.

R. A. W. C.

LEEDS, BARNSLEY AND HUDDERSFIELD

NORTH MIDLAND CENTRE

The Centre continued the session on the 4th January, 1955, with its fifth Ordinary Meeting, at which the Chairman, Mr. W. A. Crocker, presided over a meeting of some 60 members and guests, including four new Corporate Members. After the pleasing ceremony of welcome to these members, the Chairman introduced Mr. J. S. Cliff, who then read his paper entitled *The Co-ordination of Insulation of High-Voltage Electrical Installations*. This paper aroused a really vigorous discussion, opened by Mr. A. J. Coveney, who was followed by eight other members. The author, in replying to the vote of thanks ably proposed by the Chairman, expressed his pleasure at the interest shown at the meeting.

The sixth Ordinary Meeting was held on February 1st before a gathering of nearly 200 members and guests. After the Chairman, Mr. Crocker, had welcomed a new Corporate Member, and presented Book Tokens to Mr. R. Barnes and Mr. J. Botterell for their success in the Higher National Certificate examinations, he went on to introduce Dr. T. E. Allibone, who then gave his lecture entitled *Modern Developments in Atomic Energy*. Those present listened enthralled to this brilliant exposition of a subject which has captured man's imagination. At the close Dr. Allibone was kind enough to answer questions posed by several members. The vote of thanks to the lecturer, ably proposed by Mr F. Barrell, was carried vociferously.

The Faraday Lecture was delivered by Mr. T. D. B. Terroni in Leeds Town Hall on February 21st before a large audience. This fascinating description of the history of communication from earliest times, with its wealth of animated demonstrations, maintained interest from the start, and everyone present was completely in accord when Mr. D. Bellamy voiced their thanks to the lecturer for a most interesting evening.

The seventh Ordinary Meeting, which was a joint meeting with the Sheffield Sub-Centre, was held in Barnsley on March 2nd. In the unavoidable absence of the Centre Chairman, the proceedings were opened by the immediate Past-Chairman, Mr. G. Caton, who welcomed the many members of the Sheffield Sub-Centre, and greeted a new Corporate Member; he next invited Mr. F. L. Parkin, Chairman of the Sheffield Sub-Centre, to take the chair for the remainder of the meeting. The speaker, Mr. C. D. Wilkinson, was then invited to give his lecture entitled *Electricity in Mines*. This proved to be an excellent account of the mining uses of electricity from before 1914 to the present day, with a wealth of figures showing the enormously increased usage over this period, and with an indication of some likely developments in the future. The discussion, which was opened by Mr. R. Hathaway and supported by four other members, was very spirited and touched on some controversial issues. The Chairman, after expressing gratitude to the author, went on to thank Mr. J. H. J. Richards for the excellent local arrangements which he had made for this meeting.

NORTH MIDLAND UTILIZATION GROUP

At the third meeting on the 4th January, 1955, the Chairman, Mr. N. S. Goddard, announced that Mr. R. Spence was forced by business considerations to give up the Secretaryship of the Group and that Mr. G. Auton would be Acting Secretary for the remainder of the session. Mr. J. F. Cunningham expressed the Group's appreciation of the five years' work which Mr. Spence had devoted to its affairs, of his efficiency as an organizer, and of his 100% attendance during this time both as Acting Treasurer and as Secretary. Mr. Spence, replying briefly, spoke of the pleasure he received in promoting the work of the Group. The speaker, Mr. J. W. Bunting, then presented his paper entitled *Safety in the Use of Portable and Transportable Electrical Equipment in Industry*. Members found this a most sincere and thoughtful survey of the problems associated with safeguards against electric shock, and even became aware of the meaning of such phrases as "ventricular fibrillation." The discussion opened by Mr. Harrison and continued by six other members covered a considerable portion of the paper in an interesting manner, and the evening closed with a vote of thanks to the speaker, proposed by the Chairman.

NORTH MIDLAND STUDENTS' SECTION

The session has continued satisfactorily under the Chairmanship of Mr. J. E. Leeson. The annual meeting at Huddersfield took place on the 14th December, 1954, when Mr. P. H. Sinclaire presented his paper *Electrical Distribution Practice in Germany*. The author, having spent some time in Germany under an exchange scheme, held our attention with his interesting descriptions and comparisons, and a lively discussion ensued.

On the 11th January, 1955, the Section was honoured by the presence of the Centre Chairman, Mr. W. A. Crocker, who delivered his Chairman's Address, featuring for the Section's special benefit the psychology of applying for a post and, conversely, of receiving an application for one. From the start a lively interest was apparent and the lecture was followed by a spirited discussion. J. L.

LIVERPOOL AND CHESTER

MERSEY AND NORTH WALES CENTRE

The year 1954 proved successful in the Mersey and North Wales Centre, and a varied programme of papers was read in Liverpool and Chester, with an encouraging increase in attendance at the meetings. In addition, there has been a further increase in the number of District Meetings held at Llandudno, Warrington and Wrexham.

At the beginning of 1954, Mr. J. Eccles, who has rendered invaluable service on the Committee of the Centre since 1944, and who was Chairman in 1950–51, resigned on account of his new appointment as Deputy Chairman (Operation) of the British Electricity Authority. It gave the members of the Centre great pleasure to learn later in the year that Mr. Eccles had been elected President of The Institution.

The Joint Meeting with the North-Western Centre, which was held at Chester on the 1st February, 1954, again proved a very successful and well-attended meeting. It was honoured by the presence of Sir George Nelson, a Vice-President. Dr. Bowden gave a lecture entitled *Faster than Thought*, intriguing the audience with the prospect he opened out of revolutionary changes in office procedure from the development of electronic digital computors that could be programmed to carry out much routine clerical work.

The Dinner-Dance was again held at Hulme Hall, Port Sunlight, in March, 1954. As usual, this proved a most successful function both socially and financially, and the Benevolent Fund benefited handsomely. Mr. Lancaster was a very able Master of Ceremonies.

The Annual Golf Tournament was held on the Southport and Ainsdale Course on the 25th May, 1954, and whilst the weather was not as kind as it had been on previous occasions, there was an enjoyable day's golf. The G. P. Dennis Trophy was won by Mr. G. F. Sills with a score of 4 down.

At the Annual General Meeting held on the 5th April, 1954, Mr. P. R. Dunn was elected Chairman for 1954–55, and Professor J. M. Meek and Mr. E. J. Evans, Vice-Chairmen. Mr. A. V. Milton, who had been Secretary of the Centre from 1945, resigned and was succeeded by Mr. J. W. Lynn. The Centre has become accustomed to the efficient way in which its business has been conducted, and members are therefore very pleased that Mr. Milton is able to carry on as a member of the Committee.

The Annual Dinner, which was held at the Exchange Hotel, Liverpool, on the 8th November, 1954, again proved a successful social function. The principal guest, Mr. J. A. Duncan, proposed the toast of "The Institution," and the response was made by the President. Mr. T. B. D. Terroni, a Past-Chairman of the Centre, made the first delivery of his Faraday Lecture at a meeting in the Philharmonic Hall, Liverpool, on the 6th December, 1954. Mr. Terroni sketched the development of communication and fascinated his audience with his mastery of the subject and his ability to explain it to the public. In addition, the demonstrations were particularly effective and pleasing. S. T.

OXFORD

DISTRICT MEETING

A District Meeting held at the Southern Electricity Board's Offices on the evening of the 9th February, 1955, attracted 65 members and their guests to hear a paper on *Fault Location in the Supply Industry* read by Mr. Trevor David. Mr. David began his paper with an outline of the various types of cable faults and the methods of location, and with the aid of lantern slides illustrated the equipment used. He later explained the methods of locating leaks in gas-filled cables using a tracer gas that can be detected at the leak by an electronic detector. Methods of freezing the gas at various positions in the cable by means of a jacket of liquid oxygen to form a temporary barrier in order to effect a location were also explained, as well as an introduction to pulse methods of fault location. During the discussion that followed, Mr. David answered the many questions that were put to him, and he related some of his more interesting experiences. A vote of thanks was proposed by Mr. Napier. G. Z.

SHEFFIELD

SHEFFIELD SUB-CENTRE

The sixth meeting of the session was held at the Grand Hotel, Sheffield, on the 16th February, 1955, when Professor L. F. Bates read a paper on *Recent Ideas and Experiments in Magnetism*. The author outlined the experiments that had been conducted at the University of Nottingham on the theory of magnetism and demonstrated his findings by means of a large number of lantern

slides and a film. There was an extremely good attendance of members and visitors, but unfortunately the discussion had to be cut short owing to lack of time. A vote of thanks to Professor Bates was proposed by Mr. F. G. Tyack.

The Sub-Centre was fortunate to have Sir George Nelson, a Vice-President, present at this meeting, and he gave a short address on The Institution's activities before the paper was read. G. G. N.

STOKE AND STONE

NORTH STAFFORDSHIRE SUB-CENTRE

The Development and Utilization of Hydro-Electric Power in Uganda was the subject of the paper read by Mr. J. M. Stock and Mr. J. C. Lithgow at the Stoke meeting on the 14th January, 1955. The paper was of considerable general interest, and an active discussion, opened by Mr. C. C. Pimble, ranged over the whole subject from the economics of the scheme and probable growth of load to the design of plant and equipment. Coloured lantern slides showing the type of country helped considerably to a fuller appreciation of the physical difficulties to be overcome in constructing the generating station and transmission lines. A vote of thanks to the authors was proposed by Mr. H. A. P. Caddell, who said that, in addition to its technical excellence, this paper unfolded a story of real pioneering work, which gave it a special interest. It was most stimulating, especially to the younger engineers, to know that this scheme had been conceived and was being carried out by British engineers.

The Annual Dinner of the Sub-Centre, at the Crown Hotel, Stone, on February 11th, was attended by about 90 members and guests, under the Chairmanship of Mr. J. M. Ferguson. The toast of "The Institution" was proposed by Lt.-General Sir John Eldridge, and the President replied, whilst Mr. H. G. Nelson responded to the toast of "Our Guests," proposed by Dr. E. R. Patrick, Vice-Chairman of the Sub-Centre. The speeches maintained the high level of interest and entertainment which is becoming traditional at this function, and a very enjoyable evening was continued less formally by the conversazione which followed.

High-Voltage D.C. Transmission by the Post Office

A joint meeting with the Stone–Stoke Centre of the Institution of Post Office Electrical Engineers was held at Stone on February 14th, when Mr. Halsey read the paper *A Transatlantic Telephone Cable* written jointly by the American authors Dr. M. J. Kelly and Mr. G. W. Gilman, and by Sir W. Gordon Radley and himself. Before the paper was read, Mr. H. R. Harbottle welcomed The Institution members, and the Chairman, Mr. J. M. Ferguson, said it was a pleasure to join with the I.P.O.E.E. to hear and discuss such an important communication paper. He also presented an Institution Prize, awarded for the high standard attained in a Higher National Certificate examination, to Mr. W. M. Somerville.

Mr. R. W. Palmer opened the discussion, to which many members contributed, and Mr. J. E. Boul, in proposing a vote of thanks, said the paper was of absorbing interest to the power engineer as well as to those mainly concerned with communication. He referred to the very ambitious nature of the scheme and wished it every success. The Chairman humorously congratulated the Post Office on this first example of high-voltage d.c. transmission over such a long distance, and Mr. Harbottle suggested that repeaters requiring a lower voltage should be designed, since the present voltage tended to hamper the design of very long cables. L. G.

SWANSEA AND TENBY

WEST WALES (SWANSEA) SUB-CENTRE

A District Meeting was held on the 2nd December, 1954, at the South Wales Electricity Board headquarters in Tenby, when a paper entitled *Pulse Power in Radar*, was read by Capt. Lees. This was a very successful meeting, although a number of engineers were prevented from attending, damage caused by a severe gale necessitating their being on duty. The paper, which was preceded by a short film, dealt with the development of radar for use in aircraft identification, and at sea. At a meeting on December 9th Mr. J. G. Hunter presented his paper entitled *The Royal Festival Hall; Electrical Installation.* The paper created considerable interest, especially in the power-distribution arrangements.

On the 13th January, 1955, Mr. D. P. Sayers read the paper *The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems*, by Monsieur M. E. Laborde, Mr. F. J. Lane and himself. Speakers who took part in the succeeding discussion were somewhat critical of such a power link, but Mr. T. Gill, in proposing a vote of thanks to Mr. Sayers, aptly put the subject in its true perspective. Here was a problem that had demanded a comprehensive study, he said, and a valuable treatise had resulted. Whatever the outcome, much useful information had been obtained from the experimental work undertaken during its preparation.

The Faraday Lecture was delivered by Mr. T. B. D. Terroni in Swansea on February 8th. It was held in the magnificent Brangwyn Hall, which was filled to capacity. There was a very good attendance at the meeting on February 10th, when Dr. J. S. Forrest and Mr. J. M. Ward presented their paper on *Service Experience of the Effect of Corrosion on Steel-Cored-Aluminium Overhead-Line Conductors.* It was apparent from the discussion which ensued that the meeting had attracted engineers with considerable experience of overhead-line equipment, but Mr. Ward had a ready answer to all points which were raised. R. F. D.

NEWS *from abroad*

BURMA ASSOCIATION OF ENGINEERS

Members who were in Burma before the 1939–45 War will be interested to learn that efforts are being made to revive the Burma Association of Engineers. The past records of the Association were lost during the war and it is thought that former members of the Association may be willing to assist in building up these records by offering old copies of the publications of the Association which may still be in their possession. Any who are able to help in this way are requested to send such documents to the Secretary of The Institution, who will forward them to Burma.

COLOMBO

CEYLON OVERSEA BRANCH

At short notice, Mr. J. Dyson, B.Sc.(Eng.), who was staying for a few days in Colombo, agreed to address members of the Ceylon Oversea Branch on the 4th February, 1955, his subject being *Recent Trends in British Transformer Manufacture*. After an introduction by the Vice-Chairman of the Branch, Mr. S. Rajanayagam, who was in the chair, Mr. Dyson said how glad he was to have the opportunity of talking to members in Ceylon.

In his address he stressed the importance of reducing core losses in transformers, and referred to the various materials used in the core laminations for achieving this end. The growing use of cold-reduced grain-oriented steel for core lamination and its application at flux densities higher than those normally associated with cores of hot-rolled steel were discussed. Mr. Dyson stated that this allowed transformers to be built with smaller dimensions and lower losses than those of similar capacity with hot-rolled-steel core laminations. It was possible thereby to have larger units at smaller cost. The specification of impulse-voltage withstand levels and the co-ordination of system insulation were considered, as well as the various methods adopted by the United Kingdom manufacturers to grade the insulation of transformer windings. Mr. Dyson said that if capacitance were not graded, the winding resonance waves created would cause breakdowns, but with the use of a high-speed oscillograph, it was possible to determine the actual voltage at any point and thereby grade the insulation. He then described the on-load tap-changing gear and made a comparison between the resistor and reactor transition types.

A brief discussion followed, and the chairman proposed a vote of thanks to Mr. Dyson for having found the time to address members on this important subject.

KENYA AND UGANDA

It is proposed to transmit electrical power from the Owen Falls hydro-electric station, Uganda, to Nairobi, a distance of some 350 miles. The proposal includes the construction of a double-circuit single-steel-tower 132 kV line from the Uganda–Kenya border at Tororo to Nairobi, which will link with a double-circuit line already under construction by the Uganda Electricity Board from the Owen Falls to Tororo. The estimated cost of the Tororo–Nairobi section is £3 800 000.

A new company has been formed in Kenya to handle this project, and negotiations are in progress with the Kenya Government. It is hoped that the work will be complete in July, 1957.

Sir Charles Westlake, who has been intimately connected with the Owen Falls hydro-electric development, is retiring from the Chairmanship of the Uganda Electricity Board at the end of this year. He is at present the President of the East African Association of Engineers.

QUEENSLAND

The traditional Christmas Luncheon of the Queensland Oversea Committee took place at the Bellevue Hotel, Brisbane, on the 9th December, 1954, when the guest of honour was Mr. H. G. Watkin, Director-General of Education, Queensland. As in previous years the function was well supported by members, some 40 in all attending. In accordance with custom only two toasts were honoured: "The Queen" and "Our Guest." In responding to this toast Mr. Watkin gave an excellent address on secondary and higher education in Queensland.

The address by Mr. Charley, which was briefly noted in the March *Journal*, was given on the 10th February, 1955, to a joint gathering of 80 members of The Institution and The Institution of Engineers, Australia. It covered the latest innovations by British manufacturers in design, construction and installation of large transformers for voltages up to 380 kV, and it was most informative to electricity supply engineers and others concerned with the planning of the large electricity supply projects which are in rapid progress in Queensland.

This function, once again, provided ample proof of the intense interest evinced by Australian engineers in an address by an oversea expert on the latest developments in his particular speciality. A. S. F.

OVERSEA ATTENDANCE REGISTER

During the period 1st February to 28th February, 1955, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

FREW, N. J., B.Sc., B.E. (**Sydney**).
MARTIN, T. G., T.D. (**Kuwait**).
MORRIS, R. (**Bogotá**).
PROUDLOCK, R. V., Lt.-Col. (**Germany**).
SCUTT, R. H. (**Nairobi**).

OBITUARY

DAVID ALEXANDER BREMNER

David Alexander Bremner, O.B.E., who died on the 7th February, 1955, was born on the 23rd July, 1866. He received his technical training as an apprentice with the Eastern Telegraph Co. and the Brush Electrical Engineering Co. Later he became Electrical Engineer to the Port Said and Suez Coal Co., leaving them to take up the position of Electrical Engineer to the Borough of Kimberley, South Africa. He also held other engineering appointments in South Africa, including Manager of an iron works, and Chief Engineer and General Manager of the Simmer and Jack Gold Mines, both in Johannesburg, where he was at the time of the Jameson Raid (1895).

Subsequently he renewed an earlier acquaintance with Scandinavia by joining the Dunderland Iron Ore Co. as General Manager, and from 1911 to 1914 he was General Manager of the Hydraulic Power and Smelting Co. During the First World War he was head of the Aluminium Section of the Ministry of Munitions, and for his services there he was made an O.B.E. Next he became a Managing Director of Chance and Hunt at Oldbury, and in 1919 he was appointed Director of the British Engineers' Association, a post which he held until 1943, and in which he became closely connected with many industrial organizations. He was a member of the Grand Council of the Federation of British Industries and served on no less than 34 F.B.I. committees, becoming chairman of five of them. He was a member of the British National Committee of the International Chamber of Commerce and of the British National Committee of the World Power Conference. In 1928 he was elected to the Standardization and Simplification Committee of the Board of Trade and in the following year to the Mechanical Industry Committee of the then British Engineering Standards Association.

As a member of the Executive Council of the 1924 British Empire Exhibition he helped to organize the Shipbuilding, Mechanical and General Engineering Section of the Exhibition. In 1925 he was elected Vice-Chairman of the Committee of Experts of the Shipping, Engineering and Machinery Exhibition.

Mr. Bremner spoke and wrote fluent Swedish and Norwegian among other languages, and he took part in several industrial delegations to the Continent.

He joined The Institution as an Associate in 1890 and was elected a Member in 1894, being one of the Members of longest standing at the time of his death. He was also a Member of The Institution of Mining and Metallurgy.

HARRY BROCKLESBY

Harry Brocklesby, who died suddenly at Swinton, Yorkshire, on the 19th December, 1954, was born on the 4th January, 1909. He was educated at Mexborough Secondary School. From 1924 to 1929 he was apprenticed in electrical engineering to the Manvers Main Colliery Co. at Wath, and he studied at the same time at Mexborough Technical College and Sheffield University. He continued his formal technical studies until in 1933 he gained the Associateship in Engineering of Sheffield University. He also gained the First-Class and Honours Certificates (Electrical) of the Association of Mining Electrical and Mechanical Engineers. He was appointed Maintenance Electrician to the Manvers Main Colliery Co. in 1929 and he stayed with the company until 1938, when he became Chief Electrical Engineer of the Wath Main Colliery Co. Since Vesting Date he had been Chief Electrical Engineer of the South Barnsley Area of the National Coal Board, North Eastern Division.

A large part of his time and interest had been devoted to the A.M.E.M.E. He joined as a Student in 1926 and was elected a Member in 1934. He served on the Council continuously from 1943 and was very active in Committee work. He was Convener of the Prizes and Papers Committee and sat on the Advisory Committee, the Training and Education Committee and the Drafting Committee. In 1951–52 he served an initial term as Vice-President and he was re-elected a Vice-President in 1953. Only two months before his death he was nominated by the Council for election as National President in June, 1955. He had long been an active member of the Yorkshire South-East Branch of the A.M.E.M.E., of which he was President in 1948. His Presidential Address on that occasion, "Trailing Cable Repairs," became an authoritative work on the organization of cable departments in central repair shops.

During the busy years of his professional life he even found time to teach, being a part-time lecturer in mining electrical engineering at Rotherham Technical College from 1934 to 1946; he had a burning interest in education which culminated in his seat on the Board of Managers of Mexborough Technical College, of which he was indeed proud to become Chairman in 1949. Later, in 1951, he was appointed a member of the Yorkshire Mining Qualifications Board.

Mr. Brocklesby was a freemason, and a member of Wath Golf Club. He is survived by his widow.

He joined The Institution as a Graduate in 1938 and was elected an Associate Member in 1940 and a Member in 1951. He served on the Committee of the Sheffield Sub-Centre from 1944 to 1947 and again from 1951 to 1954. He was also a Member of The Institution of Mining Engineers. J. A. W.

THOMAS GOOD CRUM

Thomas Good Crum, B.Sc.(Eng.), Wh.Sc., who died on the 18th January, 1955, was born on the 3rd September, 1890. He was educated at Shawlands Academy, Glasgow, and was a graduate of Glasgow University, where he gained a Whitworth Scholarship. He served an apprenticeship with Stewart and McKenzie, Glasgow,

and in 1912 received his first appointment with the Glasgow firm of James E. Sayers and Caldwell, consulting engineers, with whom he was to make his career for life.

Shortly after the First World War he became a partner in the firm, and from early 1933, when the style was altered to James E. Sayers and Crum, he was the senior partner and, latterly, sole owner. During the past 30 years the firm has acted as consultants for the design and execution of a complete electricity undertaking for the Borough of Bangor, Northern Ireland, for a similar undertaking, including a Diesel-engined generating station of some 1 300 kW ultimate capacity, for the Dunoon and District Electricity Supply Co., and for the complete change-over from direct to alternating current and modernization of the electricity undertaking of the Burgh of Fort William, Inverness-shire. Mr. Crum was also engaged in several important colliery electrifications and steam-generating-plant installations for leading Scottish coal companies, and in the design and supervision of numerous industrial, commercial, and hospital electrical installations throughout Scotland. His most recent work was in connection with the modernizing and large scale-extensions of the electrical installation and distribution system at Glasgow University. In all his work he paid the most meticulous attention to detail.

Mr. Crum was a keen churchman, being an elder of the Church of Scotland, and an enthusiastic and accomplished violinist. He is survived by his wife, a son and a daughter.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1928. He served on the Committee of the Scottish Centre from 1929–31.

J. E. S.

I. HARDING JENKINS

I. Harding Jenkins, who died on the 5th January, 1955, was born on the 9th December, 1877. He was educated at the Merchant Venturers School, Bristol, and started his engineering career in the same town with the National Telephone Co. After a period of training with the company, he was employed on the construction and maintenance of internal plant. In 1900 he was placed in charge of the installation of the Bristol exchange, which was the first common-battery exchange to be built outside the United States. He was brought to London in 1903, and on the transfer of the company's plant to the Post Office in 1912 he entered Government service and became one of the staff of the Engineer-in-Chief. His work was concerned mainly with the development of telephone switching techniques, first in connection with the common-battery manual system and later with automatic systems, particularly the Strowger director system as used in London and other large cities. At a later stage in his career he took an active part in the development of trunk demand working, and in connection with this he visited Germany and the United States.

From 1934 until his retirement in 1938 Mr. Jenkins was Staff Engineer in charge of the Telephone Development and Maintenance Branch at the Engineering Department Headquarters. His clear insight, sound judgment, ample knowledge and wide experience made him an extremely competent engineer, while his kindly personality was such as to endear him to all who had the privilege of associating with him.

He joined The Institution as an Associate Member in 1908 and was elected a Member in 1929. A. J. G.

RICHARD HENRY MACLURE LEA

Richard Henry Maclure Lea, C.B.E., B.E., who died suddenly at his home in Adelaide, South Australia, on the 12th December, 1954, was born in Glasgow on the 25th October, 1898. He received his early education at Larchfield and Shandon House Schools in Scotland, and at Malvern College. In 1915 he was apprenticed to J. T. Thorneycroft and Co. at Southampton, but in the following year he enlisted, and was commissioned in 1917 as a lieutenant in the King's Royal Rifle Regiment; he was twice wounded and was taken prisoner. In 1921 Mr. Lea went to Adelaide, where apart from a short period of surveying for the Australian Government on the North–South Railway, his whole working life was spent with the Adelaide Electric Supply Co. (which became, in 1947, the Electricity Trust of South Australia). After completing his engineering studies at the University of Adelaide, most of which were done in his spare time whilst he was working as a meter tester, he was appointed Technical Assistant to the Distribution Engineer. He rose rapidly in his profession and was appointed Country Lines Superintendent in 1927, Assistant Manager in 1936, and Chief Engineer and Manager in 1947. With the continued growth of the organization, a separate Chief Engineer was appointed in 1953, Mr. Lea retaining the position of General Manager.

During the Second World War, he served in the Australian Electrical and Mechanical Engineering Corps, commanding an Australian Army Field Workshop in the Middle East and gaining the rank of Lieutenant-Colonel. His spirit of comradeship and helpfulness is shown in the active part he took in work connected with the Armed Forces. He was a Past-President of the Adelaide Legacy Club, a member of the original executive of the Fighting Forces Comfort Fund and a foundation trustee of the World War II Services Welfare Fund.

Mr. Lea was one of the outstanding administrators in the Australian electricity supply industry. He was a member of the Executive Committee of the Electricity Supply Association of Australia, and a Past-Chairman of the section dealing with power generation; he had retired from the Presidency of this Association just before his death. For his many services to the public he was made a C.B.E. in the Coronation Honours List.

He was a man of great enthusiasm and vigorous personality who took delight in handling difficult assignments, and, by the example he set, gained the full support and enthusiasm of all who worked with and

for him. He was a manager who valued the friendship of every employee, who recognized the dignity of labour and service in every form and who constantly strove to see that every man was adequately recompensed for his service.

He joined The Institution as an Associate Member in 1937 and was elected a Member in 1948. G. H. M.

FRANK NICHOLLS

Frank Nicholls, who died on the 21st December, 1954, was born on the 4th May, 1886. He received his engineering education at the Battersea Polytechnic and began his career with James Simpson and Co. of Newark-on-Trent. From 1907 to 1913 he was employed by the Royal Mail Steam Packet Co., with whom his work was concerned not only with electrical, but also with marine and hydraulic, engineering.

His first post in the electricity supply industry was with the Heston and Isleworth Urban District Council, with whom he stayed from 1913 until 1917, when he left to join the Birmingham Corporation Electricity Department.

In 1920 he took up an appointment as boiler-house superintendent with the Derby Corporation Electricity Department, and was successively promoted to the positions of Deputy Borough Electrical Engineer and Borough Electrical Engineer. During his period of service with the Derby undertaking he carried out considerable experimental work on pulverized-fuel boiler plant, at a time when this method of firing was in the course of early development. In 1939 he was appointed City Electrical Engineer and Manager to the Leeds Corporation, a position which he held until nationalization of the industry, when he became Manager of the No. 4 (Leeds) Sub-Area of the Yorkshire Electricity Board, and he remained in this post until his retirement in May, 1951.

He took an active interest in the various organizations within the supply industry and served for a number of years on the District Joint Industrial Council, and on the Councils of the British Electrical Development Association, and of the Incorporated Municipal Electrical Association.

In 1946 he visited the United States and made a study of power-station development there, in order to take advantage of any improvements that might be usefully embodied in the Skelton Grange power station, which was at that time being built by the Leeds electricity undertaking. Upon his retirement from the Yorkshire Electricity Board he became a director of the Leeds Industrial Engineering Co.

F. N., as he was affectionately known, was a courteous, kindly and modest man, and was always ready to give a helping hand to younger members of his staff.

He joined The Institution as an Associate Member in 1924 and was elected a Member in 1942. He served on the Committee of the East Midland Sub-Centre from 1925 to 1929, and again from 1932 to 1937, and he was Chairman of the Sub-Centre in 1931–32. He served on the North Midland Centre Committee from 1940 to 1943. He was also a Fellow of the Institute of Fuel.

T. H. C.

CHARLES LIONEL ERNEST STEWART

Charles Lionel Ernest Stewart, who died at Exeter on the 17th November, 1954, was born in the year 1878.

His general education was at St. Paul's School and his technical education at Finsbury College, London. He received his early training with Johnson and Phillips, and in the Mechanical Engineer's Department of the Post Office. A period was spent in Liverpool as a shift engineer from 1898 to 1900, when he became Chief Assistant Electrical Engineer to the Rochdale Corporation; his next appointment was as Borough Electrical Engineer and Tramway Manager to the Rawtenstall (Lancashire) Corporation in 1909, at the age of 31, with whom he remained until he retired in 1931.

The Rawtenstall Corporation Electricity Undertaking was inaugurated just after his appointment; it comprised a small station, which gave, from its beginning, bulk supplies to the neighbouring Borough of Bacup. Bulk supplies were also extended to the town of Haslingden in 1915, thereby linking with the Accrington generating station.

During the First World War Mr. Stewart took an active part in the local production of munitions, which was set up in factories and workshops throughout the country under the Minister of Munitions.

Mr. Stewart was the first Secretary of the Mid-Lancashire Electricity Advisory Board set up under the 1919 Act. As a tramway engineer he took an active part in the formulation of electricity tariffs for tramway undertakings, and was an authority on the problem of earth-leakage currents from tramway rails; he wrote a monograph on this subject for the Municipal Tramway Association. He was also the author of a book entitled "Organization and Administration of the Electricity Undertaking," which was published in the Pitman Municipal Series in 1925.

For a number of years he acted in a consultative capacity to small undertakings, e.g. Earby and Silsden in Yorkshire, and Haslingden in Lancashire, and also to many mills in the Rossendale Valley during the time of change-over from steam to electrical drive.

He was a man of many parts, motoring being his main hobby. He married but had no children. In everything that he undertook, his keenness to achieve success was remarkable. Like many other engineers, he found time to take up golf only late in life, but here again he applied his engineering skill (aided by a slide rule) to work out the intricacies of the game.

He joined The Institution as an Associate Member in 1901 and was elected a Member in 1924. He served on the Devon and Cornwall Sub-Centre Committee from 1942 to 1944. J. E. S.

CORRESPONDENCE

Cross-loaded Frequency-Boosters

From M. G. NASH, *Associate Member*

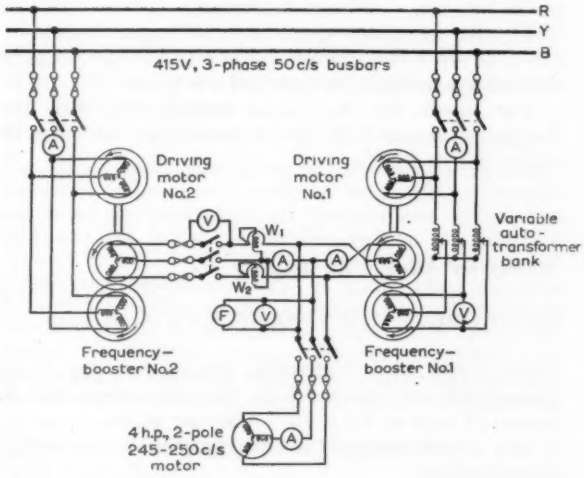
The following is an account of a machine load-testing problem, concerning a motor-driven frequency-booster which was designed to give a continuous 3-phase 250c/s output of 20kVA from its rotor terminals. Four such sets constituted the installation, the output from each supplying five 2-pole 4h.p. squirrel-cage motors of special design.

It was intended that these motors should be started direct-on-line, but some doubt was expressed as to the adequacy of the frequency-booster rating, especially under the condition when four motors were running on full load and the fifth was switched in. None of the special 4h.p. motors was initially available for test purposes; however, an alternative 4h.p. 250c/s motor and its load were obtained, with reputedly similar characteristics.

A test circuit was arranged as shown in the Figure, a simulated load of four fully loaded motors being applied to the frequency-booster set under test, using an adjacent set, while the single available 4h.p. machine was used to give the condition of starting the fifth motor. Frequency-boosters Nos. 1 and 2 were run up to speed and paralleled through the switch-fuse, using a voltmeter. By adjusting the variable auto-transformer controlling the field of frequency-booster No. 1, a load could be imposed on frequency-booster No. 2 similar in magnitude and power factor to that of four fully loaded 4h.p. motors.

With this load on frequency-booster No. 2 the substitute 4h.p. motor was switched in, but it refused to run up to speed, crawling at 882r.p.m. and producing noise and vibration. Further attempts, one with the capacity of frequency-booster No. 1 alone, and the second with the two frequency-boosters connected in parallel but not cross-loaded, proved unsuccessful, the motor crawling with attendant noise and vibration each time. The sets were next shut down and the motor was connected direct to the terminals of frequency-booster No. 1. This machine was then run up to speed, the motor running up perfectly to 14 800r.p.m.

It was decided to investigate the reason for this peculiar performance, and it was first assumed that the crawling was due to parasitic harmonic magnetic fields. To eliminate the possibility of harmonics appearing in the waveform of frequency-booster No. 2, a reactive load equivalent to 125% of the full-load value of kilovolt-amperes was imposed on this machine by cross-loading, and a waveform analysis carried out. The results showed the largest harmonic present to have an amplitude of only 1·6% of the fundamental. The cause of crawling was thus inherent in the motor, whose rotor had 35 slots. Any squirrel-cage motor whose total number of rotor



A test circuit for a frequency-booster

slots differs by unity from a multiple of the number of main poles will have in its air-gap a series of rotating fields produced by the rotor currents. If two of these fields have numbers of poles differing by two, unbalanced magnetic forces will arise from them, of magnitude proportional to the products of the amplitudes of their components. This series of fields is given by:

$$S = 2Gd + p \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where p = number of poles of the inducing stator field,
G = number of rotor conductors, and
d = any positive or negative integer, or zero.

For the motor under consideration, the series of multiple fields set up by the 17th stator harmonic ($p = 34$), by substitution in (1) above, is $+34$, -36, $+104$, -106, $+174$, -176, etc. This is an infinite series of fields which are grouped in pairs having numbers of poles differing by two, and which therefore set up unbalanced forces. It is suggested that these forces deflected the rotor shaft, reducing the air-gap on one side of the rotor and increasing the unbalanced magnetic attraction, and thus adding to the original disturbing force. As the rotor accelerated, the speed of the force vector varied through a wide range (this is shown below), and at 882r.p.m. coincided with the critical rotor speed, causing

Mr. Nash was formerly with the United Kingdom Atomic Energy Authority, and is now with the United Sulphuric Acid Corporation.

vibration and preventing further acceleration of the rotor.

The speed, v, of the force vector is given by:

$$v = Gn - 2f \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where n = rotor speed, r.p.s.,
f = supply frequency, c/s, and
G = number of rotor conductors.

At standstill, $n = 0$ and $v = -500$ r.p.s., and at synchronism, $n = 250$ and $v = 8\,250$ r.p.s.; i.e. the speed of the force vector, by substitution in eqn. (2) above, varies between -500 and 8 250 r.p.s.

At the crawling speed $n = 14{\cdot}7$ r.p.s. and $v = (35 \times 14{\cdot}7) - (2 \times 250) = 14{\cdot}7$ r.p.s., i.e. the speeds of the force vector and the rotor are the same.

The reason for the motor running up with the frequency-booster itself can be seen from the Table of values of v, n and f.

v	n	f	v	n	f
0	0	0			
485·6	14·7	14·7	4 950	150	150
1 650	50	50	6 600	200	200
3 300	100	100	8 250	250	250

The speed of the force vector did not now coincide with the critical rotor speed, and hence no vibration or crawling occurred.

When the correct motor and its load came to hand the foregoing load test was repeated. The motor ran up successfully at each attempt. The correct motor had 34 rotor slots, and consequently no parasitic field of sufficient magnitude to cause crawling could arise.

Acknowledgment is made to the Chief Electrical Engineer to the United Kingdom Atomic Energy Authority Office for permission to publish this letter.

"Henry per Metre." An Absurdity

From LAURENCE H. A. CARR, M.SC.TECH., *Member*

Some writers, most regrettably, specify the value of the permeability of free space in the rationalized M.K.S. system of units as $4\pi \times 10^{-7}$ *henry per metre*.

Any natural constant of this type has three principal characteristics:

(*a*) Its dimensions, which, for the permeability of free space, are well known to be equal in the [L], [M], [T], [Q] system, to $[LMQ^{-2}]$; and to a corresponding expression, if a factor other than [Q] is taken for the electromagnetic basic dimension.

(*b*) Its numerical value, which depends on the system of units concerned. Here there is no conflict of opinion—the numerical value of μ_0 in the rationalized M.K.S. system is agreed to be $4\pi \times 10^{-7}$.

(*c*) The unit in which that numerical value is expressed, which again depends on the system of units concerned.

From (*b*) it is inherent that in the rationalized M.K.S. system the unit of permeability (whatever other name it may be given) is $1/(4\pi \times 10^{-7})$ of the permeability of free space.

But we are now being asked by some people to use as a unit for this quantity the "henry per metre." In order to determine what this means it is necessary to introduce the definition of the henry. A convenient form of words is that used by Say* to the effect that inductance in henrys is equal to the number of "electromagnetic linkages per ampere." From this it follows that on the henry-per-metre basis, the unit of permeability is "unit electromagnetic linkage per ampere per metre," and this, a unit defined in circuit parameters, is the unit to be adopted for specifying one of the fundamental constants of the universe, the one which, for want of a better title, we call the "permeability of free space."

Could anything be more absurd?

The misconception appears to have arisen from an attempt to extend the theory of dimensions into the hypothesis that the units themselves on each side of an equation shall not merely be equivalent, but shall be identical. In the majority of mechanical problems this causes no difficulty, but in electromagnetic problems, where the factor μ_0 occurs in many different fundamental formulae, although its *dimensions* remain unchanged, the *unit* in which it is expressed must be given a variety of forms, if the names of the individual units are required to equate or to cancel out in every equation. For example, in the equation relating B to H, μ_0 would need to be expressed in "webers per square metre per ampere-turn per metre."

Other definitions would be necessary when other equations were considered; e.g. the equation corresponding to the fundamental definition of the ampere in the M.K.S. system; the law of the mechanical force due to a magnetic field; and the equation for the e.m.f. produced by motion in a magnetic field of strength H. But of all the possible, and confusing, variations, the henry per metre is the worst.

It therefore seems that the only logical course to adopt is to say, as above, that the unit of permeability is $1/(4\pi \times 10^{-7})$ of the permeability of free space. Since this is inherent in the bare statement that $\mu_0 = 4\pi \times 10^{-7}$, this, without mention of units, is all that is required to be, and indeed should be, specified in a textbook or standard laying down the value of this natural constant.

The objection to the use of "farads per metre" as the unit for the permittivity of free space, though perhaps not quite so strong, can be supported on similar grounds; here again, it is sufficient to give for this constant simply the numerical value which corresponds to the system of units employed.

* SAY, M. G.: "Electrotechnology and Calculations" (George Newnes, 1947), p. 33.

Mr. Carr is with the Metropolitan-Vickers Electrical Co. Ltd.

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A list of papers published in the April issue of Part A of the Proceedings appears under "Contents of the Current Issues of the Proceedings" on page 275, and the serial number of each paper and the month of publication of a digest in the Journal is included. Synopses of both Monographs and papers which will be published separately before the next issue of the Journal appear below, and unless otherwise stated, their date of publication is the same as this issue of the Journal. The Monographs will be republished in Part C of the Proceedings, and the relevant Part for the republication of a paper is given after the serial number of the paper.

MONOGRAPHS

R. F. SAXE, Ph.D., and Professor J. M. MEEK, D.Eng.

The Initiation Mechanism of Long Sparks in Point-Plane Gaps

MONOGRAPH No. 124 M

Investigations have been made of the optical and electrical characteristics of the corona discharges and leader strokes preceding the impulse breakdown of positive-point/negative-plane gaps in air at atmospheric pressure. The results show that initially a corona discharge forms in the highly stressed region round the pointed electrode; this corona gives rise to a short (0·4microsec approx.) pulse of light emission in the gap, accompanied by a similar pulse of current in the circuit. The size and shape of the light-emitting volume in this corona discharge have been studied. The next stage in the growth of the spark is the development of the leader stroke from the corona. The leader stroke grows across the gap in a predictable manner, the current that flows in the circuit during the growth depending on the velocity of the leader stroke. The size and configuration of the light-emitting volume of the leader stroke are similar to those of the corona. The characteristics of the corona and leader stroke in air at reduced pressures and in oxygen, nitrogen and hydrogen are also briefly described.

A digest of the Monograph will be published in Part B of the *Proceedings*.

W. E. LEWIS, Ph.D., and J. H. BANKS, B.Sc.

Matrix Methods for the Evaluation of Simultaneous Faults in Three-Phase Systems

MONOGRAPH No. 125 S

The Monograph illustrates two methods whereby the steady-stage impedance matrix in terms of symmetrical-component parameters may be obtained for a 3-phase system with multiple unsymmetrical faults. In the first method all faults are replaced by a balanced condition for which the symmetrical-component impedance matrix is easily obtained using Stigant's Rule. This matrix is then transformed to that of the faulted network by means of a connection matrix and relationships developed by Kron. The second method shows how Stigant's rule may be used to write down the impedance matrix of the symmetrical-component network representing the unsymmetrical system.

A digest of the Monograph will be published in Part A of the *Proceedings*.

P. E. W. GRENSTED, M.A.

The Frequency-Response Analysis of Non-Linear Systems

MONOGRAPH No. 126 M

If a non-linear system is oscillating, either through external excitation or internal regenerative action, it may be possible to show that the waveform at the input to the non-linear elements in the system is approximately sinusoidal. In such a case the frequency-response analysis may be carried out on the assumption that all harmonic components generated by the non-linear element can be ignored.

The Monograph discusses, with reference to feedback control systems, the results that can be obtained if this approximation is made. The amplitude, frequency and stability of steady self-excited oscillations are derived. Transient oscillations may be considered only in systems governed by second-order differential equations, but in these systems an analytic expression for the variation of frequency and damping with time, and hence for the full solution, is derived. Several examples, all relating to "on-off" controllers, and comparing the approximate and exact solutions, are given; the accuracy obtained both for transient and steady oscillations is about 10%.

A digest of the Monograph will be published in Part B of the *Proceedings*.

J. H. MASON

Breakdown of Solid Dielectrics in Divergent Fields

MONOGRAPH No. 127 M

The paper shows that breakdown channels propagate from

needle-point electrodes embedded in polythene and polyisobutylene when the maximum effective stress at the end of the point reaches the intrinsic electric strength of the material at the test temperature. The average breakdown stress shows no significant variation with the radius of curvature of the point (for radii of 1–20μ), but (at room temperature) about 25% greater stress is required with a negative than a positive point. This result is explained by the effect of enhanced conductivity and consequent space-charge accumulation increasing the effective point radius some 25μ for a positive and about 45μ for a negative point.

The decrease of the average stress required for breakdown with increasing electrode separation is explained, and the same concept is used to predict the variation of the industrial electric strength of materials with specimen thickness. Factors affecting the industrial electric strength of materials are discussed and illustrated by tests on polythene, polystyrene and cellulose acetate, using B.S. electrodes in air, and in clean and contaminated transformer oil.

A digest of the Monograph will be published in Part B of the *Proceedings*.

PATRICK T. G. FLYNN, B.Sc., Ph.D.

Field-Dependent Conductivity in Non-Uniform Field Distributions and its Relation to Electrical Breakdown

MONOGRAPH No. 128 M

A method is given for calculating the resulting field distribution when the conductivity is a function of the field strength. This is applied to a point-plane electrode system in an amorphous solid with the assumption that the conductivity at low field strengths is electronic and that the conductivity at high field strengths is described by a relation due to Fröhlich. The results show that for polymethylmethacrylate with average fields of the order of 10^6 volts/cm, the reduction in maximum field strength from that calculated for constant conductivity can be a factor of five or more, the magnitude of the reduction depending on the degree of non-uniformity of the field. Energy-level data required for the calculation are given for glass, polyethylene, polymethylmethacrylate and several types of varnish, and incomplete data are given for chlorinated polyethylene, polystyrene and polyisobutylene. The results are applied to breakdown in a non-uniform field, and a method is suggested for determining experimentally whether breakdown occurs when the maximum stress reaches the intrinsic electric strength, or whether it is necessary for the stress to exceed this over a given distance.

A digest of the Monograph will be published in Part B of the *Proceedings*.

W. S. PERCIVAL, B.Sc.

The Graphs of Active Networks

MONOGRAPH No. 129 R

The results obtained in previous papers are employed to develop the properties of the graphs of linear networks which may contain valves and transformers. A reduced graph is obtained which facilitates the setting up of the determinant of the network. This graph may be split into two separate graphs, termed the current and voltage graphs, such that there is a one-to-one correspondence between every algebraic operation on the H-matrix and every topological operation on the graphs. Thus every problem which can be solved with the one can be solved with the other. The derivative of a graph with respect to a network element corresponds to the derivative of an H-determinant with respect to a network element. With an extended definition of a tree on a network, the set of trees on any network is shown to be equal to the nodal determinant of the network. Practical applications of the methods described are outlined.

A digest of the Monograph will be published in Part B of the *Proceedings*.

N. F. ASTBURY, M.A., Sc.D., F.Inst.P.

Residual Effects in the Campbell Bridge Method for the Absolute Measurement of Resistance, and a Note on a New Bridge

MONOGRAPH No. 130 M

Systematic errors, associated with coil reversals, in the determination of the absolute unit of resistance by Albert Campbell's a.c. bridge method, originally noted by Hartshorn and Astbury and recently confirmed by Rayner, can, it is shown, be explained by uncompensated eddy-current coupling between supply and detector circuits. It is also shown that the errors are largely, but not necessarily completely, eliminated when a mean value is taken. A new bridge is proposed in which, by measuring an additional mutual inductance, the effect can be eliminated without external compensation: it is also indicated how this might be done, less conveniently, on the Campbell bridge. A model of the new bridge, operating at 1 kc/s, has been used to demonstrate experimentally the introduction of systematic variations associated with coil reversals, the eddy currents being produced under control in a tertiary circuit.

A digest of the Monograph will be published in Part B of the *Proceedings*.

PAPERS

H. I. ANDREWS, Ph.D., M.Sc., M.I.Mech.E.

The Adhesion of Electric Locomotives

PAPER No. 1797; PART A

After the results of previous investigations have been considered, the paper describes measurements of adhesion made on electric locomotives on the recently electrified lines between Manchester, Sheffield, and Wath. Measurements were made under controlled conditions with the aid of the mobile testing plant on one driving axle of a locomotive—the tractive effort of this axle being separately regulated—and on all driving axles of a locomotive in normal condition, while the adhesion of locomotives working trains in service was observed by the use of dynamometer cars.

It is shown that there exists a relationship between adhesion and speed, and between adhesion and water on the head of the rail, while variations in adhesion were found to occur between different parts of the track. Methods of temporarily improving adhesion were investigated, such as the use of sand or of certain esters. The conclusions are considered particularly in relation to the working of trains up the Wentworth incline, and recommendations are made as to the methods of driving to be employed under difficult conditions.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH MARCH, 1955

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	29	6 386	3	0
£5 to <£100	735	8 173	9	4
£2 to <£5	1 793	5 010	15	7
Under £2	17 162	9 142	6	11
		£34 712	14	10

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

NEW YEAR HONOURS LIST

The name of the following member of The Institution was included in the New Year Honours and Distinctions conferred by Her Majesty, but was inadvertently omitted from the list published in the February *Journal*.

O.B.E.

Connor, R. (*Associate Member*).

ANNUAL GENERAL MEETING OF THE INSTITUTION

THURSDAY, 19TH MAY, 1955, AT 5.30 P.M.

Notice is hereby given that the Annual General Meeting of The Institution of Electrical Engineers will be held on Thursday, 19th May, 1955, at 5.30 p.m., at the Institution Building, Savoy Place, London, W.C.2, to receive and consider the Accounts for the year ended 31st December, 1954, and the Annual Report of the Council, and to elect Auditors.

Copies of the Accounts and Report (which will in due course be published in the *Journal*) can be obtained on application to the Secretary about ten days before the date of the meeting.

By order of the Council,

W. K. BRASHER,
Secretary.

LECTURE BY THE RT. HON. LORD CITRINE, P.C., K.B.E.

Members are reminded that the Annual General Meeting on the 19th May will be followed at approximately 6.30 p.m. by a lecture on "Human Relations in Industry" by the Rt. Hon. Lord Citrine, P.C., K.B.E.

ELECTIONS AND TRANSFERS

Particulars of 242 elections and 248 transfers approved by the Council will be found on page 272.

NOMINATIONS

BRITISH ELECTRICAL POWER CONVENTION

The Council have nominated Mr. R. W. Mountain, B.Sc.(Eng.), Member, to serve on the Council of the British Electrical Power Convention in place of Mr. T. G. N. Haldane, M.A., Past-President.

B.S.I. ENGINEERING DIVISIONAL COUNCIL

The Council have nominated the President to serve on the above Council in place of Sir John Hacking, Past-President.

REGIONAL ADVISORY COUNCIL FOR HIGHER TECHNOLOGICAL EDUCATION (LONDON AND HOME COUNTIES): ELECTRICAL ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. N. C. Stamford, M.Sc., Member, to serve as their representative on the above Committee in place of Mr. F. R. Livock, B.Sc.(Eng.), Member.

REGIONAL ADVISORY COUNCIL FOR THE ORGANIZATION OF FURTHER EDUCATION IN THE EAST MIDLANDS: ADVISORY PANEL FOR THE ENGINEERING INDUSTRY

The Council have nominated Mr. C. Grad, Associate Member, to serve as their representative on the above Panel.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

Members who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of Institutions concerned is now as follows:

Country	*Institution*
Australia	Institution of Engineers, Australia.
Belgium	Société Royale Belge des Ingénieurs et des Industriels.
	Société Belge des Électriciens.
Brazil	Instituto de Engenharia, São Paulo.
Canada	Engineering Institute of Canada.
Denmark	Dansk Ingeniørforening.
Finland	Suomalisten Teknikkojen Seura.
	Tekniska Föreningen i Finland.
France	Société des Ingénieurs Civils de France.
	Société Française des Électriciens.
Germany	Verein Deutscher Ingenieure.
Holland	Koninklijk Instituut van Ingenieurs.
Iceland	Association of Chartered Engineers in Iceland.
India	Institution of Engineers, India.
Italy	Associazione Elettrotecnica Italiana.
Japan	Institute of Electrical Engineers of Japan.
New Zealand	New Zealand Institution of Engineers.
Norway	Norsk Elektroteknisk Forening.
	Norsk Ingeniørforening.
South Africa	South African Institution of Civil Engineers.
	South African Institute of Electrical Engineers.
	South African Institution of Mechanical Engineers.
Sweden	Svenska Teknologföreningen.
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein.
Turkey	Turkish Engineering Society.
United States	American Institute of Electrical Engineers.
	American Institute of Chemical Engineers.
	American Institute of Mining and Metallurgical Engineers.
	Institute of Radio Engineers.

The Secretary will gladly give letters of introduction to members visiting these countries.

HANDBOOK FOR AUTHORS

A second edition of The Institution's "Handbook for Authors" has recently been published. The price is 3s. (post free), but, on application to the Secretary, a single copy will be supplied free of charge to anyone who is preparing a paper for submission to The Institution.

The range of acceptable subject-matter for papers is as wide as the range of professional interests of members of The Institution, and no attempt is made to suggest suitable subjects or detailed methods of treatment. The handbook does, however, include an outline of the broad classes of papers which are acceptable, and this may assist a prospective author to decide whether, and in what form, to submit his material. This outline is followed by chapters on the arrangement of material, the preparation of manuscripts and the checking of proofs, and the oral presentation of a paper.

The facilities available in the Institution building, from lifting tackle to optical projectors, and from d.c., single-phase and 3-phase supplies at various voltages to gas (in cylinders at 7 days' notice); the reprints to which authors are entitled, and the premiums which may be awarded; guidance on the reproduction of Institution material in other publications, and on the reproduction of copyright material in the publications of The Institution—these are some of the other matters connected with the preparation, presentation and publication of Institution papers which are covered in the handbook.

The handbook concludes with a list of the authorities which are consulted by the Institution staff—on non-technical words, and on technical terms, symbols and abbreviations—and a glossary of the names of quantities and their symbols, with the units in which the quantities are measured and their abbreviations, based largely on B.S. 1991, "Letter Symbols, Signs and Abbreviations. Part 1. General," which was published in April, 1954.

EXEMPTION FROM THE INSTITUTION EXAMINATION

DEGREES IN PHYSICS, GENERAL SCIENCE, AND MATHEMATICS

The Council have recently reconsidered the position of those wishing to join The Institution who hold degrees in Physics, General Science or Mathematics, in regard to their possible exemption from the Institution Examination. As a result, they have issued the following revised regulations on this point and these are now being incorporated in the Examination Regulations:

There are two alternative avenues of entry to The Institution for those whose education has been predominantly that of a physicist but who take up electrical engineering work of a professional character. Election into the class of Graduates can first be obtained by the satisfaction of the requirements of the Institution Examination. The extent of the exemption from the subjects of this Examination will be determined in each individual case by the Council and the decision may lie between complete exemption on the one hand for the holder of a first-class honours degree in physics of a British university, and a requirement at the other extreme that the candidate must sit for a maximum of four electrical subjects, for example one in Part II and three in Part III of the Institution Examination. Similar consideration will be given to graduates in mathematics, who in certain circumstances may be required to sit for the subject of Engineering Physics, in addition to the specified electrical subjects.

The second avenue is that appropriate to a more advanced stage in a candidate's career when he may be eligible for election to the class of Associate Members. If such a candidate's practical training and subsequent responsible experience are approved by the Council, he may be granted exemption from certain subjects of the Institution Examination for which, at an earlier stage, he might have been required to sit.

WIRELESS TELEGRAPHY ACT, 1949

REGULATIONS ON INTERFERENCE FROM SMALL MOTORS AND REFRIGERATORS

It will be recalled that in 1950 and 1952 the Postmaster General appointed, under Section 9 of the Wireless Telegraphy Act, 1949, two Advisory Committees, with whom he proposed to consult before making regulations concerning wireless interference from various types of refrigeration apparatus, or from fractional-horse-power motors and electrical appliances embodying such motors.

The Advisory Committee on Wireless Interference from Refrigeration Apparatus, under the Chairmanship of Mr. F. T. Chapman, C.B.E., D.Sc.(Eng.), Member, was appointed on the 26th July, 1950, and the Advisory Committee on Wireless Interference from Small Motors, under the Chairmanship of Mr. J. R. Beard, C.B.E., M.Sc., Honorary Member, was appointed on the 26th March, 1952. As with the Advisory Committee on Wireless Interference from Ignition Systems, whose report led to the making of regulations in 1953, the secretariat for the Committees was provided jointly by the Post Office and The Institution.

The reports of the two Committees were transmitted to the Postmaster General, and on the 1st March, 1955, the following regulations based thereon were laid before Parliament:

S.I. 1955, No. 291. The Wireless Telegraphy (Control of Interference from Electric Motors) Regulations, 1955.

S.I. 1955, No. 292. The Wireless Telegraphy (Control of Interference from Refrigerators) Regulations, 1955.

The Regulations empower the Postmaster General to control interference with reception of sound broadcasting and television which arises from refrigerators, and from domestic and industrial appliances which are driven by small electric motors, e.g. vacuum cleaners, hair driers, and drills.

Both sets of regulations come into force on the 1st September, 1955. They state the requirements which must be met by (*a*) manufacturers, assemblers and importers of all electrical refrigerators, and (*b*) users of new and old electric f.h.p. motors (i.e. including those used in refrigerators).

The requirements are prescribed in terms of the maximum permissible r.f. voltage within specified frequencies, at the supply terminals. Regulation 4 and the Schedule of each Statutory Instrument set out the method of measurement and the description and specification of the measuring apparatus.

The maximum permissible r.f. voltage at the terminals of both refrigerators and other small-motor-driven appliances is 1 500 microvolts for the waveband 200–1 605 kc/s (the major part of the broadcast band) and 750 microvolts for the waveband 40–70 Mc/s [the existing television band (Band I)]. For small-motor-driven appliances in use it is further required that the field strength of the radiated electromagnetic energy at a distance of 33 ft in any direction shall not exceed 100 microvolts/metre for the waveband 200–1 605 kc/s or 50 microvolts/metre for the waveband 40–70 Mc/s.

These limits have necessarily been based on data derived from existing sound and television broadcasting services, for which they are designed to give adequate protection in areas of moderate field strength, provided the receiving installation, including the aerial system, is satisfactory. It is hoped that the measures taken in compliance with the Regulations will be of substantial service in protecting reception of the

frequency-modulated sound broadcasting services to be provided in Band II (87·5–100 Mc/s) and will contribute to satisfactory reception in Band III (174–216 Mc/s) to be used for the television service of the Independent Television Authority.

In regard to small-motor-driven appliances, the Postmaster General hopes that there will be a progressive extension of the current practice of certain manufacturers of producing appliances that incorporate suppressors, or of providing for the easy addition of a suppressor if it proves necessary. The question of making the regulations for small-motor-driven appliances apply to manufacturers is to be reviewed during the next two years.

The Advisory Committees, when submitting to the Postmaster General their reports upon which the present regulations are based, recommended that information should be issued drawing attention to the importance of earthing in accordance with the Wiring Regulations issued by The Institution. It was pointed out that the requirement of earthing contained in the Wiring Regulations assumed even greater importance when interference suppressors were fitted to an appliance; exceptions to the requirement of earthing were "all-insulated" and "double-insulated" appliances, and appliances used in "earth-free" situations. It was also important that components of suitable quality should be used for interference suppression, and that they should be properly installed. These two aspects of interference suppression are dealt with, respectively, in B.S. 613, "Components for Radio-Interference Suppression Devices," and the Code of Practice, "General Aspects of Radio Interference Suppression" (shortly to be published).

MEASUREMENTS SECTION

SUMMER VISIT, 1955

The Summer Visit of the Measurements Section will take place on Friday, 17th June, 1955. The members and their ladies will visit the works of Electrical and Musical Industries Ltd., Hayes, at the invitation of the Directors, and after lunch will proceed to the Royal Horticultural Society's Gardens at Wisley. In the evening the party will visit the British Electricity Authority's Training Establishment, Horsley Towers, East Horsley, at the invitation of the Authority, where tea will be served.

A circular giving details of the visit will be dispatched to all members of the Section with the May *Journal*.

CONVENTION ON DIGITAL COMPUTERS

The Committees of the Measurements and Radio Sections, in collaboration with the D.S.I.R. Advisory Committee on High-Speed Calculating Machines, and with the approval of the Council, have arranged a Convention on Digital Computer Techniques to be held at the Institution building in April, 1956. Details will be announced later.

SYMPOSIUM ON AIRCRAFT ELECTRICAL EQUIPMENT

The Utilization Section Committee are sponsoring a Symposium of papers on Electrical Equipment of Aircraft, to be held in the Spring of 1956. A special Panel, on which the Radio Section Committee is represented, has been appointed to make the arrangements.

JOINT CONFERENCE ON COMBUSTION

THE INSTITUTION OF MECHANICAL ENGINEERS AND THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Institution of Mechanical Engineers is arranging, in conjunction with the American Society of Mechanical Engineers, to hold a joint Conference on Combustion. This will be held in two parts, the first in the United States at the Massachusetts Institute of Technology, from the 15th to 17th June, 1955, and the second in London, in the Great Hall of The Institution of Civil Engineers from the 25th to 27th October, 1955. The same papers will be presented in the United States and in Great Britain, and the discussions in both places, together with the papers, will be published as one volume of the *Proceedings of The Institution of Mechanical Engineers*.

The objects of the Conference will be:

(i) To link theory and practice in combustion by presenting theoretical results to practical engineers.

(ii) To provide an opportunity for practical engineers to meet and discuss practical applications of theory to boilers, furnaces, internal combustion engines, and gas turbines.

It is expected that around 30 Institutions and Societies from the Commonwealth and Europe will support the Conference, in addition to those from the United States. Some 45 papers, of which about 20 are being provided by the American Society of Mechanical Engineers, will be presented —in the form of résumés by reporters—under five sections. Advance copies of the papers are now available and may be bought from The Institution of Mechanical Engineers.

In London the Conference will hold six sessions; these comprise the presentation and discussion of papers in the five sections, General, Boilers, Industrial Furnaces, Internal Combustion Engines, Gas Turbines, and finally a discussion of the more important matters arising during preceding sessions.

Members of the participating Institutions and Societies must register their names if they wish to take part in the Conference. This registration also gives members the right to purchase the publications of the Conference, both in their advance and final forms.

Any members of The Institution wishing to register should apply for an application form to the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2. Further details of the Conference can, if necessary, be obtained from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

INTERNATIONAL CONFERENCE ON THE INDUSTRIAL APPLICATIONS OF NUCLEAR ENERGY

L'Association des Ingénieurs Électriciens sortis de l'Institut Montefiore are organizing on the 3rd and 4th May, 1955, an International Conference on the Industrial Applications of Nuclear Energy, which will be held in Liège, Belgium, on the occasion of the International Fair there. The Conference will be opened by Monsieur Jean Rey, Minister of Economic Affairs in Belgium, and will comprise addresses by engineers from Belgium, France, Great Britain, Holland, Italy, Sweden, Switzerland and the United States.

The fee for participation, which includes the right to a copy of the proceedings of the Conference, is 250 Belgian francs. Further particulars may be obtained from le Secrétaire Général de l'A.I.M., 31 rue St.-Gilles, Liège, Belgium.

STUDENTS' QUARTERLY JOURNAL

The contents of the March issue of the *Students' Quarterly Journal* include the following articles and papers:

The Siting and Construction of Steam Power Stations, by A. S. Gilchrist.

Waveguide Techniques, by M. H. Alder, B.Sc.(Eng.).
This subject brings to mind the fact that the *S.Q.J.* published in 1940 one of the first papers, if not the first, on this subject in Britain.

Vacation Work in the United States, by C. Pilling.
This deals, in an interesting and amusing way, with a student member's experiences last summer.

Solid Insulation, by Margaret K. Weston, B.Sc.(Eng.).

Some Mathematical Fallacies, by J. T. Hayes, B.Sc.(Eng.).

An Introduction to the Study of Servomechanisms, by P. J. Bhatt, B.Sc.(Eng.).

The Aims of a Monitoring System, by Sheila M. Weir, B.Sc.

Distribution of Electricity, by J. S. Johns.

The Application of Electricity to Horticulture, by S. G. Griffiths.

Welding Methods, by J. M. Stewart.

A Modern Application of Diesel-electric Propulsion, by P. W. R. Gatcliff, B.Sc.

The Application of Radio-Frequency Heating to the Textile Industries by A. R. Bailey, B.Sc.

TELEMETERING CONFERENCE IN CHICAGO

The National Telemetering Conference, sponsored by the American Institute of Electrical Engineers, the Institute of Radio Engineers, the Institute of Aeronautical Sciences, and the Instrument Society of America, will be held in Chicago from the 18th to 20th May, 1955. The Conference, which now takes place annually, covers all fields of telemetering and includes a large number of papers; this year's Conference is accompanied by an exhibition. Members are invited to attend, and they can obtain full particulars from Mr. W. J. Mayo-Wells, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N.Y., United States.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT
621.317.333

The A.E.G. High-Voltage Institute; festive publication on the occasion of the inauguration of the Institute in Kassel

4to. pp. 87. Berlin: A.E.G., 1954.

An illustrated description of a high-voltage research institute and short-circuit testing station. Articles discuss the development of short-circuit testing, the theory of the subject, methods of testing, and a 2 000 MVA short-circuit generator.

BANNER, E. H. W. 621.317.7

Electronic Measuring Instruments

8vo. pp. 403. London: Chapman and Hall, 1954. £2 5*s*. *

Reviews first the general principles of electrical indicating instruments and then discusses the characteristics of hot- and cold-cathode valves, cathode-ray tubes, photocells, and metal and crystal rectifiers. The operating principles of instruments incorporating these devices are next described. The last part of the book deals with counters, recorders and gauges employing electro-mechanical transducers, thermistors and magnetic amplifiers. The book was reviewed in the January isue.

BECKETT, C. S. 621.31

Generation and Transmission

3rd ed. 8vo. pp. 130. London: Blackie, 1954. 8*s*. 6*d*. *

Deals with both the steam and electrical sides of modern generating stations and with overhead and underground transmission systems.

BENSON, F. A. 621.3(076)

Electrical Engineering Problems with Solutions

8vo. pp. 232. London: Spon, 1954. 25*s*. *

A collection of problems and the solutions suitable for post-intermediate level students.

BETTRIDGE, B. R. 621.314.63

Transistors and Crystal Diodes: What they are and how to use them

8vo. pp. 72. London: Price, 1954. 5*s*. *

A practical account of the way germanium diodes and transistors work, with circuits in which actual values of components are given. These circuits lead up to a description of a complete receiver in which thermionic valves are entirely replaced by transistors now available.

BRANS, P. H. 621.385

Television and Special Tubes Vade-Mecum. 1954

11th ed. 4to. pp. 215. Antwerp: Brans, 1954. 26*s*.

BRUCKSHAW, J. McG. 621.317.44

Magnetic Variometers of the Schmidt Type: Their full use and maintenance illustrated by details of the Hilger and Watts variometers

8vo. pp. 119. London: Hilger and Watts, 1954. 22*s*. *

BUTTRESS, F. A. 413

World List of Abbreviations of Scientific, Technological and Commercial Organizations

8vo. pp. 267. London: Leonard Hill, 1954. 18*s*.

BYERS, H. R. 551.594

Thunderstorm Electricity

8vo. pp. 348. Chicago: University of Chicago Press, 1953. 45*s*. *

A collection of 16 articles by specialists representing the latest theoretical and practical knowledge of the subject.

CARR, T. H. 621.311.17

Electric Power Stations, Vol. 1

4th ed. 8vo. pp. 615. London: Chapman and Hall, 1954. £3 10*s*.* .

Deals with the general principles governing the design, construction and operation of power stations. A brief survey of the materials used and the construction of many items of plant and equipment is given.

COTTON, H. 621.31

Applied Electricity

3rd ed. 8vo. pp. 496. London: Cleaver-Hume, 1954. 18*s.* 6*d.* *

Based primarily on Part I of the London B.Sc.(Eng.) degree, it covers adequately the most recent requirements of a group of examinations, including the Engineering Institutions' Part I examination, and the National Certificates. The fundamentals of electricity and magnetism are included so that the volume shall completely satisfy the student's needs. Contains many worked examples and also examples to be worked by the student. This edition has been rearranged so that it is based on the rationalized M.K.S. system of units.

CROW, L. C. 621.318.3

Design, Construction and Operating Principles of Electromagnets for attracting Copper, Aluminium and other Non-Ferrous Metals

8vo. pp. 42. Vincennes, Indiana: Scientific Book Publishing Co., 1951. 10*s.*

Simple laboratory experiments demonstrating the phenomena.

ESHBACH, O. W. (EDITOR) 53(083)

Handbook of Engineering Fundamentals

2nd ed. 8vo. pp. 1 134. New York: Wiley. London: Chapman and Hall, 1952. £4

Fundamental mathematical, physical and chemical data and formulae with some information on metallic and non-metallic materials used in engineering.

FORSYTH, W. E. (EDITOR) 53(083)

Smithsonian Physical Tables

9th ed. 8vo. pp. 833. (Smithsonian Miscellaneous Collections, vol. 120. Publication 4169.) Washington: Smithsonian Institution, 1954. £4

This book was reviewed in the March Journal.

HAYASHI, C. 534

Forced Oscillations in Non-Linear Systems

4to. pp. 172. Osaka, Japan: Nippon Printing and Publishing Co., 1953. 36*s.* *

A theoretical and experimental investigation of steady-state and transient conditions.

92 (Parsons)

The Hon. Sir Charles A. Parsons, Born One Hundred Years ago on 13th June, 1854

8vo. pp. 39. Newcastle upon Tyne: C. A. Parsons and Co. Ltd., 1954.

A very brief biography which deals almost entirely with his engineering achievements.

HUNT, F. V. 621.395.6

Electroacoustics: the Analysis of Transduction, and its Historical Background (Harvard Monographs in Applied Science No. 5)

8vo. pp. 266. Cambridge, Massachusetts: Harvard University Press. New York: Wiley, 1954. £2 8*s.* *

A modified formulation of the electromagnetic relations involving the introduction of a "space operator" allows all transducer types to be represented by the same form of equivalent circuit. This is demonstrated by applying it to representative electromagnetic and electrostatic types. The book was reviewed in the March Journal.

JASWON, M. A. 539

The Theory of Cohesion: An outline of the cohesive properties of electrons in atoms, molecules and crystals

8vo. pp. 249. London: Pergamon Press, 1954. 37*s.* 6*d.*

Develops the mathematical and physical arguments involved in the theory of cohesion from a general idea of wave mechanics and the mathematics involved to a full treatment of cohesion in aggregates and, particularly, metals.

JOHNSON, J. R. 413

Color TV Dictionary

8vo. pp. 70. New York: Rider, 1954. 12*s.*

Definitions of terms used in colour-television engineering arranged in dictionary order and based on the National Television System Committee definitions.

LANG, R. (EDITOR) 53

Laboratory and Workshop Notes 1950–52: A third selection reprinted from the *Journal of Scientific Instruments*

8vo. pp. 290. London: Arnold, 1954. 30*s.* *

A third volume of Workshop Notes reprinted from the "Journal of Scientific Instruments" 1950–1952.

LYON, W. V. 621.313.3

Transient Analysis of Alternating-Current Machinery: An application of the method of symmetrical components

8vo. pp. 318. New York: The Technological Press of Massachusetts Institute of Technology and Wiley. London: Chapman and Hall, 1954. £2 16*s.* *

Uses an analysis based on the Kirchoff differential equations that apply to the machine and the connected system. Shows how Fortescue's method of symmetrical components can be used to determine the transient behaviour under different operating conditions.

LAWDEN, D. F. 517

Mathematics of Engineering Systems (Linear and Non-Linear)

8vo. pp. 386. London: Methuen. New York: Wiley, 1954. 30*s.* *

Provides a link between the calculus textbooks suitable for an engineering degree course and advanced books on the theory of functions of a complex variable. Explains the classical method of solving differential equations and modern methods using transforms, and their applications to the analysis of approximately linear systems. Deals with the response of linear systems to the step functions and harmonic inputs, and the relationship between open-loop harmonic response and the stability of feedback systems, but the emphasis is on the mathematical method rather than the engineering problems.

MACGREGOR-MORRIS, J. T. 92(Fleming)

The Inventor of the Valve; a Biography of Sir Ambrose Fleming

8vo. pp. 141. London: Television Society, 1954. 10*s.* *

The author, who was once a student under Fleming and later his assistant, and who has a remarkably retentive memory of past events, has written a brief but interesting account of Fleming's life as a teacher and an inventor.

PUCHSTEIN, A. F., LLOYD, T. C., AND CONRAD, A. G. 621.313.3

Alternating-Current Machines

3rd ed. 8vo. pp. 731. New York: Wiley. London: Chapman and Hall, 1954. £3 8*s.* *

This expanded and revised edition of a well-known work retains the same form but the approach to the theories of some machines has been modified, including more detailed developments of vector diagrams, methods of calculating the cross-axis voltages of synchronous machines and equations describing the oscillations of synchronous motors.

THE JOURNAL REFERENCE SECTION *(pages 268-276)*

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Elections and Transfers

The following elections and transfers were approved by the Council during February and March, 1955.

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BISBY, Harry, B.Sc.
CHALMERS, James Rutherford.
COOPER, Albert Roscoe.
DUNCANSON, William Eric, M.Sc., Ph.D., D.Sc.
DURANT, Ronald Frederick.
ELLIOT, Ernest Walter.
FAUGHNAN, Cathal, B.E.
GORDON, Sidney Charles.
GREEN, Robert Leonard.
GREENWOOD, Leonard Edwin, Instr. Lt.-Cmdr., R.N., B.Sc.
GUNN-RUSSELL, Charles, M.A.
HANSFORD, Elsie Florence (Miss), B.Sc.(Eng.).
HIGGINS, Norman James.
HUCKLE, Leslie William.
JONES, Cyril Harry Edward.
KEMP, Reginald.
KENNION, Wilfrid Roger.
LAWRANCE, Graham Francis, B.Sc.(Eng.).
LOCK, Norman Reginald.
LYNAS, Thomas William.
MERRIMAN, Horace Owen, B.A.Sc.
NICOL, Kenneth Martin, M.A.
O'CONNOR, Raymond Joseph, B.Eng.
PAYNTER, Douglas Arnold.
PICKUP, Donald.
RIDGERS, William Arthur.
TURNER, Ralph, M.Sc.
WARD, Cecil Vivian.
WEISLITZER, Joseph, Dipl.Ing.
YOUNG, Kenneth John, B.A.

Associates

DE, Rabindra Kumar.
HARDMAN, Frederick, Lt.-Cmdr. (L), R.N.Z.N.
HOLLOWAY, Stanley Dennis.
HYMAS, Eric Watson.
MAINGI, Suraj Parkash.
MIDDLETON, Eric John.
OAKES, Francis.
OVERTON, Frank Gregory.
SANDY, Raymond Harry John.
SHANKAR, Muthuswamy Vishwanath.
SPEECHLEY, Ernest.
STEPHENSON, Harry.
SUTCLIFFE, John Hector.
TAYLOR, George.
WELTI, Arthur Lennox.

Graduates

ABLITT, Kenneth George.
ANDREWS, Graham William.
AYRES, Neville Leigh.
BOOKLESS, Peter Robert Cecil, B.Sc.(Eng.).
BRIGHTING, Peter Kaye.
BRYANT, Ralph Thomas.
BURNS, Russell Westcott, M.Sc.
CHAMBERS, Robert Wilson, B.Sc.
CLARK, Alan Edward.
COATES, George.
CROOK, Kenneth.
DALLOW, Raymond William.
DALTON, William Francis, B.E.
DIX, Peter Cyril.
DOWNING, Alan George.
ELLIOTT, Anthony Charles.
ELWOOD, William Norman.
FINCH, Michael James, B.Sc.(Eng.).
GRATTON, Charles Peter, B.Sc.
HARRISON, Edwin.
HUNTER, Joseph Johnston.
HUTCHINSON, John Norman, B.Sc.
JECKS, Roy George, B.Sc.
JOHN, Maldwyn Noel, B.Sc.
KENT, Donald Arthur.
KNOX, Ernest John, B.E.
LAWRENCE, Alan Henry.
LEWIS, Robert.
LOWE, John Alfred, B.Sc.(Eng.).
LOXLEY, Graham Edward Bernard, B.A.
McCANN, Arthur Anthony.
MACHIN, Roy.
METCALFE, Harry Graham.
MORRIS, Alfred William.
MUNNS, John David.
NEWTON, Charles.
ODDIE, Michael Brian.
PINNER, Gerald Leonard.
RATCLIFF, John Albert.
RAVEN, Dennis Edgar.
RHODES, John Wright.
RICHARDSON, Peter, Pilot Officer, R.A.F., B.Sc.
RICKINSON, Dennis.
RODGER, Alexander.
SENGUPTA, Rathindra Nath.
SERGEANT, Victor, B.Sc.(Eng.).
STEPHENSON, Kenneth Walker, B.Sc.
STODDART, David Lloyd.
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THOMPSON, William Wilson.
TIDSWELL, Harold.
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VIDELO, Donald Albert, B.A.
WAREING, George Kenyon.
WATT, William Brown.
WHITE, James Edward Bernall, B.Sc. (Eng.).
WILLIAMS, Arthur Routledge.

Students

ALHASANI, Ali Mohammed Ali.
ANAND, Prithi Paul Singh.
ARMITT, Roy Jesse.
ASHBY, Thomas Edward.
BAGE, Brian.
BAMJI, Eruch Jal.
BANDARANAYAKE, Ananda Wickremaratne.
BANNISTER, Gerald Brian.
BARKER, Victor Allan.
BATES, John Reginald.
BEAUVAIS, Anthony John.
BELL, John Stanley.
BENT, Arthur.
BINNS, Kenneth John.
BOXALL, Herbert.
BRENTFORD, Malcolm.
BULLIVANT, John Geoffrey.
CARHART, Jack Charles Richard.
CHESTER-WALSH, Richard James.
CHOW, Kungta.
CLARKE, Ronald George.

Students (contd.)

CLASPER, Henry.
CLAYTON, Barrie.
COLE, John Allan.
COOK, Colin.
COOKE, Martin Eric.
COOPER, Brian James.
CRIDGE, Lance Neville.
DALAL, Anil Baran.
DANIEL, William Royden.
DATE, Madhav Waman.
DAVIES, William Elfyn.
DINGLE, Brian John.
DODD, Philip John.
DOWD, Brian William.
DU BARRY, James Joseph.
DUBBER, Thomas Albert.
DWIVEDI, Parmatma Prasad.
ENGLAND, John Frederick Lishman.
ENSOUR, Ali Yousef.
EVANS, Donald Richard John.
EVERETT, Patrick Nixon.
FATMI, Haneef Akhtar.
FAYLE, Alan.
FERGUSON, Alistair.
FONG, Jeffrey Tse Wei.
FORSHAW, Hedley.
FRAZER, Derek Clark.
GAMMIE, John Gordon.
GAVIN, Michael Sean.
GOPINATH, Anand.
GOW, Maurice Fred, B.Sc.(Eng.).
GRAY, Clifford Bruce.
GRAY, Keith James Kenneth.
GREEN, Roger Donald.
GREENBERG, Maurice Bernard.
GWYTHER, Harold Francis Garfield.
HAILE, Wolde Hanna.
HANKINSON, Lewis Peter.
HARRIS, David Tom.
HARRISON, William Derek.
HILTON, James Francis.
HIND, Eric.
HINDLEY, Roy.
HOLLIDAY, Bryan.
HOPE, Richard Arthur.
HORNE, Sydney Mark Kenneth.
ILES, Kenneth Raymond.
IZATT, Jack Birrell.
JARMAN, Theodore Kingsford.
JEFFERSON, Brian Martin.
JONES, Henry Joseph.
JONES, Kenneth Robert.
JONES, Peter Reginald.
JONES, Robert Pryce.
KAY, Frederick Norman.
KINGSLEY, James Herbert.
LAMBERT, Peter Gabriel.
LANGFORD, John Ian.
LATHAM, Francis Gerard.
LEAK, Malcolm Saunders, B.Sc.
LEUNG, Ting Kui.
LLOYD, Lewis John.
MACHIN, Roland.
McROBB, Neil Farquharson.
MAGOWAN, James Alexander.
MANN, David.
MARNOCH, Derek George.
MARTIN, John Tinkler.
MASHETER, David.
MATHEWS, Geoffrey Stephen.
MEESON, John Kenneth.
MOORE, Edwin Alfred.
MURPHY, Brian.
NEWTON, Arthur George.
O'SULLIVAN, Maurice Anthony.
PACKER, George Arnold.
PARKER, Leslie Harold John.
PARREN, Robert James.
PEPPER, Alan.
PRESS, Graeme William.
PRITTY, David Walter.
QUEEN, James.
RAJADEVA, Subramaniam.
RAMSHAW, Raymond Southern.
RANGER, John Maynard.
READ, Kenneth George.
RILEY, Gordon Henry.
ROWBERRY, Timothy John.
SALISBURY, Kenneth Percy.
SCOTT, John Cessford.
SHARMA, Narayan Krishna.
SHERWOOD, Stuart.
SHORT, John.
SLATER, Norman Thomas.
STABLES, Alistair Mitchell.
STAMPS, Reginald John.
STEPHEN, Douglas Alan, B.Sc.
STRACHAN, Kenneth Robert.
SUTTON, Michael Anthony, Pilot Officer, R.A.F.
TAYLOR, Lionel Charles.
TROMANS, Kenneth.
VENEIK, Amar Nath.
VISWANATH, Chandrasekariah Krishnarao.
WALKER, Brian.
WALLER, James Raymond.
WEDLOCK, Thomas James.
WHINNETT, William Peter.
WHITE, Geoffrey.
WILD, Peter.
WILLACY, Douglas James.
WONG, Liang Keen.
WOOD, Michael William Harold.
WOOD, Richard Argent.
WOODWARD, Raymond.
WRIGHT, Brian.
WRIGHT, Ian Wheldon.
YOUNG, James.
ZISSOS, Dimitrios.
ZOE, Mei Sung Malcolm.

TRANSFERS

Associate Member to Member

ASHTON, Norman.
ATCHLEY, Kenneth Wilmot, B.Sc. (Eng.).
BIRD, John Frederick, B.Sc.
BIRD, John Richard, B.Sc.(Eng.).
BROOKE, Hugh Allan, B.Sc.(Eng.).
CLARK, Gilbert.
CRIDLAND, Charles Elliott Tapscott.
DRAKE, Bernard, B.Sc.(Eng.).
GILCHRIST, Thomas Alfred.
GOODWIN, Frederick William.
GORHAM, Maurice Laver.
GRANT, John Campbell, M.Sc.
HARDY, Arthur, B.Sc.(Eng.).
HARRIS, Robert John, B.Sc.(Eng.).
HOYLE, William Dickon, B.Sc.Tech.
JONES, Horace Frederick, B.Sc.(Eng.).
KING, George, B.Sc.(Eng.).
LASH, Alfred Reeves.
LEWITT, Sidney Alfred, B.Sc.(Eng.).
LYNCH, Hugh James Alexander, Cmdr. (L), R.N.
MIRANDA, Frederick John, Dr.Ing.
NEWHAM, Ronald Hayden.
OSBORNE, Stanley Frank.
PARKINSON, William Lonsdale, B.Sc.
PRIESTLAND, Arthur Douglas.
ROSS, Daniel.
SMAIL, George Grey, B.Sc.

Associate Member to Member (contd.)

SWANN, Eric Dennis.
TANNER, Ernest Basil Thornton.
THOMPSON, Henry Christian, B.Sc.
WINTLE, Thomas Daniel Guy.
WORTLEY, Edwin Derek, M.A.

Associate to Associate Member

AITKEN, Andrew, M.A.
BELL, Eric Joseph.
CRIDLAN, Douglas Edward.
EDDISON, Donald.
EVANS, John Emlyn.
GILMOUR, Ronald Robert.
HADDRILL, Arthur Geoffrey Lionel.
HARRAP, Laurence Henry.
HARRISON, Mowbray.
NEWELL, George Frank.
STUBBINGTON, Charles John.

Graduate to Associate Member

ADAM, Ian Ross, B.Sc.
ADAMS, Brian Frederick.
AITCHISON, Thomas Walker.
ANTHONY, Leonard Charles.
BACHE, Harry, M.Eng.
BAILEY, James Thomas.
BAILLIE, George.
BAKER, David John.
BALL, Roy.
BALLANTYNE, George Kello, B.Sc.(Eng.).
BARTLETT, Arthur.
BEESLEY, John Trevor, B.Sc.Tech.
BENN, Donald, B.Sc.(Eng.).
BLACKBURN, Peter Alan, B.Sc. (Eng.).
BLYTH, Douglas Thomas.
BODY, Richard Sidney, B.Sc.(Eng.).
BOOTE, Dennis.
BRAIN, Ralph Peter George.
BRIXTON, Edwin James.
BROADBENT, Derek, B.Sc.
BROOKS, Alan Howard.
BROOME, David Armitage Spears, B.Sc.
BROWNE, Alexander.
BURRELL, Charles Edwin, B.Sc.
BURT, Thomas Spears, B.Sc.
BUTCHER, Victor Leonard.
CAMPKIN, Colin.
CASS, Wilfred Richard.
CLARK, Thomas Harold, B.Sc.(Eng.).
CLIVES, Stanley William.
COLLINS, Peter.
COOPER-JONES, Dennis Leslie, B.Sc.(Eng.).
CRANFIELD, Kenneth William.
CROOKS, John Peter, B.Sc.
CROSS, John Leonard.
DALTON, Alan Wood.
DAVIES, Hugh John James, B.Sc. (Eng.).
DAWSON, John Douglas.
DELLOW, Frank.
DOUGHTY, Douglas Campbell, B.Sc.(Eng.).
DRAYTON, Cyril Robert.
EDDOWES, Harry Arthur Leslie, Lt. (L), R.N., B.Sc.
ENGINEER, Rustom Bomanji.
EVANS, Charles Glynne, B.Sc.
EVANS, Robert Hunter, B.Sc.
FIGG, Douglas William.
FITCH, Richard Anthony, B.Sc.(Eng.).
FOORD, Thomas Richard, B.Sc. (Eng.), Ph.D.
FORSTER, John Arnold.
FRAY, Joseph.
FRENCH, Richard Alston, B.Sc. (Eng.).
GADEK, Mieczyslaw.
GANGULI, Ajit Kumar.
GARDNER, Roland Charles.
GIFFIN, Henry Daniel, B.Sc.(Eng.).
GREATOREX, Charles Albert, B.Sc. (Eng.).
GREEN, William Joseph.
GRIFFITH, Rhodri Pennant, B.Sc.
GRIFFITHS, Robert Kendall.
GRIFFITHS, William Frederick, B.Sc.(Eng.).
HALL, Cyril John, B.Sc.
HALL, Stephen James.
HARDING, Douglas John, B.Sc. (Eng.).
HARPER, Richard Frederick.
HARRIS, Albert John, B.Sc.(Eng.).
HART, Charles Frederick.
HARTLAND, George William.
HASLAM, Mark Dewhurst, B.Sc.Tech.
HASLETT, Michael James, B.Sc. (Eng.).
HAWKER, Thomas Gwyn, B.Sc.
HEATH, Arthur Richard.
HELLAWELL, Kenneth Christopher.
HENDERSON, James Lyn, B.E.
HENLEY, Jeremiah Henry, B.Sc.
HEWITT, Peter Vincent.
HOLLWAY, John Fynes.
HOOD, Robert Montgomery.
HOWES, Raymond Colin William.
JONES, John Ernest, B.Sc.
JUDD, Arthur William.
KEYS, Peter Brian, B.Sc.
KIRSCHNER, Nathan, B.Sc.
KORAM, Edmund Manteaw, B.Sc. (Eng.).
LAMECH, John Raja.
LANGLANDS, Robert Craig, B.Sc. (Eng.).
LEE, Frank Chew, B.E., B.Sc.
LITTERICK, James Grierson.
LOCKEY, George.
LORCH, Hugh Olaf.
LUXMORE, Samuel.
MACHIN, Kenneth Ewart, M.A., Ph.D.
MAJOR, John Henniker.
MARTIN, Cyril Frederick, B.Sc. (Eng.).
MEE, Graham Edmund, Lt.-Cmdr. (L), R.N.
MITCHELL, Christopher Meredyth, M.A.
MITRA, Rotu Lal.
MORLEY, Michael Costin.
MURPHY, Joseph.
NEWSON, Henry.
NORMAN, Arthur Ernest.
ODDY, Jack.
O'REILLY, William Gerard.
PENNINGTON, Raymond, B.Sc.
PORAY, George, Dipl.Ing.
PORTER, Arthur Wilfrid.
REDDIE, James William, B.Sc.(Eng.).
ROSS, Geoffrey.
SAUNDERS, Patrick William.
SCUTT, Reginald Herbert.
SEWTER, John Baron.
SHEPHERD, Gerald.
SIMS, Henry Gordon.
SLACK, John Kenneth, B.Sc.(Eng.).
SMITH, Bernard James.
SMITH, James.
SMITH, James Irvin.
SMYRL, Robert Leslie, B.Sc.
STARLING, George Anthony Walter.
STEVENSON, Alexander William.
STONE, Norman Percy.
STONEHOUSE, Bernard Hugh, B.Sc. (Eng.).
TAIT, James.
THOMAS, George Ronald.
TOMKINSON, Dennis.
TURNER, Anthony Ernest.
WADHAM, Conway Walter.
WALLER, John David.
WARD, Ivor Frederick George.
WASTELL, Frank Ernest.
WATSON, Kenneth Clyde.
WATT, James, B.Sc.
WHATMOUGH, Robert Henry, B.Sc (Eng.).
WIGGINS, John Raymond.
WILLFORD, Robert Albert, B.Sc.
WOOD, Ernest Edward.
WOOD, Harold Baker, B.Sc.
WYE, William George Henry.
YOUNG, Victor Leslie.

Student to Associate Member

BUXTON, Robert Edward, B.Sc. (Eng.).
CROWCROFT, Peter Lester.
LEE, Kenneth William, B.Sc.
MEEK, Geoffrey, Lt. (L), R.N., B.A.
PITTS, John Patrick, B.Sc.(Eng.).
SHILSTON, Paul David, M.A.
THOMASON, John Austin, B.Sc.
WEBBER, Denis Charles, B.Sc.
WEST, William Ralph.

Student to Graduate

ARNOLD, Hugh Richard.
BEHENNA, Joshua John.
BELL, Ronald Robert.
BERNSTEIN, Melville Sydney.
BEWS, John.
BLANN, Brian David Francis, B.Sc.
BOTTERELL, John Peter.
BRADFORD, Joseph.
BROMLEY, John Pearson, B.Sc. (Eng.).
CROSS, Douglas Neil, B.Sc.
CROSSLEY, Clive Gordon, B.Sc.Tech.
EASTON, James Campbell.
EDWARDS, Colin Reginald, B.Sc. (Eng.).
FLITTER, Peter.
FOSTER, John Rea, M.Sc.
GWILLIAM, Peter George Arthur.
HARBORNE, Anthony Hugh Walter, B.Eng.
HIGGINS, Francis Ignatius, B.Sc.
HOBBIS, Allan James, B.Sc.(Eng.).
HOBSON, Edward Walter, B.Sc. (Eng.).
HODSON, Peter Ruffley.
HOWE, Michael Henry, B.Sc.(Eng.).
HUDSON, George Sydney Thomas.
KEELING, Edward.
KING, Peter John.
LATHAM, Ronald Whittaker, B.Sc. (Eng.).
LOWE, Graham Victor Camden.
MACKEAND, James Crawford Brunton, B.Sc.
MARSH, Roger Teagle, B.Sc.(Eng.).
MARSLAND, Trevor, B.Sc.(Eng.).
MELLERS, John, B.Sc.Tech.
NEGUS, Arthur John, B.Sc.
NEWTON, Cyril Edward, B.Sc.(Eng.).
OLIPHANT, Alastair Purdie, B.Sc.
PARKER, Norman, B.Sc.
PARKINSON, David Percival, B.Sc. (Eng.).
PERKINS, Michael Froude, B.Sc. (Eng.).
PIOTROWICZ, Czeslaw, B.Sc.
POTTER, Ian Alexander Isaac, B.Sc.
RENSHAW, John Frederick.
RITCHIE, William Malcolm, B.Sc.
ROBINSON, Wilfred John, B.Sc.
ROBSON, Robert Stanley, Pilot Officer, R.A.F., B.Sc.
ROGER, James, B.Sc.
ROGERS, Eric James.
SERCOMBE, Geoffrey.
SMITH, Herbert Francis.
SNELL, John.
STARKEY, Alfred, B.Sc.
STARKEY, Alfred, B.Sc.
TEDFORD, David John, B.Sc.
THOMAS, John Henry Cole, B.Sc.
THOMAS, Malcolm Gwyn.
THOMAS, Peter Arthur.
THOMPSON, Peter, B.Sc.Tech.
TULLOCH, William.
TYLER, Peter, B.Sc.(Eng.).
WILKINSON, Derek.
WORTHINGTON, Gordon, B.Sc. Tech.

Local Honorary Treasurers of the Incorporated Benevolent Fund

East Midland Centre	*R. C. Woods*
Irish Branch	*A. Harkin, M.E.*
Mersey and North Wales Centre	*D. A. Picken*
North-Eastern Centre	*D. R. Parsons*
North Midland Centre	*J. G. Craven*
Sheffield Sub-Centre	*W. E. Burnand*
North-Western Centre	*W. E. Swale*
North Lancashire Sub-Centre	*G. K. Alston, B.Sc.(Eng.)*
Northern Ireland Centre	*G. H. Moir, J.P.*
Scottish Centre	*R. H. Dean, B.Sc.Tech.*
North Scotland Sub-Centre	*P. Philip*
South Midland Centre	*W. E. Clark*
Rugby Sub-Centre	*H. Orchard*
Southern Centre	*G. D. Arden*
Western Centre (Bristol)	*A. H. McQueen*
Western Centre (Cardiff)	*D. J. Thomas*
South-Western Sub-Centre	*W. E. Johnson*

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	**O**	ORDINARY MEETING
Ex	EXTRA MEETING	**R**	RADIO SECTION
I	INFORMAL MEETING	**S**	SUPPLY SECTION
M	MEASUREMENTS SECTION	**U**	UTILIZATION SECTION

After each paper that has now been published is added the month that its synopsis appeared in the *Journal*.

1955

APRIL

18 *Monday* — H. W. SWANN, O.B.E., will open a discussion on "Domestic Circuits and Protection Devices"* — **I**

19 *Tuesday* — R. DAVIS, M.SC., will open a discussion on "The Measurement of Impulse Voltages and Currents with special reference to the Testing of Surge Diverters"† — **M**

20 *Wednesday* — G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.) — **R**
"A Study of the Long-Term Emission Behaviour of an Oxide-Cathode Valve" (Paper No. 1790)‖ *Synopsis:* March, 1955

21 *Thursday* — W. SHOCKLEY, B.SC., PH.D. — **O**
The Forty-Sixth Kelvin Lecture on "Transistor Physics"*

22 *Friday* — K. R. STURLEY, PH.D., B.SC., will open a discussion on "Technical Training in North-West Germany"* (at 6 p.m., tea at 5.30 p.m.) — **E**

27 *Wednesday* — G. F. PEIRSON, A. H. POLLARD, B.SC., *and* N. CARE — **S**
"Automatic Circuit Reclosers" (Paper No. 1717)‖ *Synopsis:* December, 1954

28 *Thursday* — H. I. ANDREWS, M.SC., PH.D. — **Ex**
"The Adhesion of Electric Locomotives" (Paper No. 1797)‖ *Synopsis:* See page 262

MAY

2 *Monday* — H. V. HIGGITT — **R**
Informal Lecture on "A Simple Introduction to Telegraph Codes"‡

3 *Tuesday* — PROFESSOR W. V. MAYNEORD, D.SC. — **M**
Lecture on "Medical Uses of Radioactive Isotopes"*

4 *Wednesday* — SIR HAROLD HARTLEY, K.C.V.O., C.B.E., F.R.S.
First Graham Clark Lecture on "The Engineer's Contribution to the Conservation of Natural Resources"* (Joint Meeting with The Institution of Civil Engineers, and The Institution of Mechanical Engineers at The Institution of Civil Engineers, Great George Street, S.W.1)

5 *Thursday* — W. GREY WALTER, M.A., SC.D. — **U**
Lecture on "The Electrical Activity of the Brain"*

11 *Wednesday* — Group of papers on "Transistors and other Semi-Conductor Devices": — **R and M**

W. L. STEPHENSON, B.SC.
"Measurements of Junction Transistor Noise in the Frequency Range 7–50 kc/s" (Paper No. 1811)‖ *Synopsis:* March, 1955

G. R. NICOLL, B.SC.
"Noise in Silicon Microwave Diodes" (Paper No. 1671) (Published in the *Proceedings*, Part III, September, 1954)

R. A. HILBOURNE, B.SC., *and* D. D. JONES, M.SC.
"Transistor Power Amplifiers" (Paper No. 1861)§

L. H. LIGHT, B.SC., *and* P. M. HOOKER, B.SC.
"Transistor D.C. Convertors" (Paper No. 1862)§

J. M. WADDELL, M.A., S. E. MAYER, PH.D., *and* S. KAYE, B.SC.
"A Diffused Impurity Germanium Junction Photo-Electric Cell" (Paper No. 1860)§

* No advance information will be available.
† An abstract of the introduction will be available in advance.
‡ A synopsis will be available in advance.
§ This paper will be published not later than 10 days before the date of reading.
‖ This paper has now been published (see page 261).

12	*Thursday*	W. J. OOSTERKAMP, M.A., PH.D., *and* G. M. ARDRAN, M.D., will open a discussion on "Image Intensification in Radiology"†	Ex
17	*Tuesday*	Questions Night* (At 6 p.m., tea 5.30 p.m.)	E
18	*Wednesday*	D. B. IRVING, B.SC. "The Supply of Electricity in the London Area" (Paper No. 1748)‖ *Synopsis:* November, 1954	S
19	*Thursday*	Annual General Meeting *followed by* . THE RT. HON. LORD CITRINE, P.C., K.B.E. Lecture on "Human Relations in Industry"* (At approximately 6.30 p.m.)	
21	*Saturday*	Utilization Section Summer Visit to the Atomic Energy Research Establishment, Harwell	U

JUNE

6 to 11	*Monday to Saturday*	Summer Meeting in the North of Scotland	
17	*Friday*	Measurements Section Summer Visit to Electric and Musical Industries, Hayes; Wisley Gardens; and the British Electricity Authority's Training Establishment, Horsley Towers, East Horsley	M
25	*Saturday*	Radio Section Summer Visit to Rugby	R

* No advance information will be available.
† An abstract of the introduction will be available in advance.
‖ This paper has now been published (see page 251).

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DATE OF JOURNAL DIGEST OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (APRIL, 1955)

Digest not yet published
J. B. YOUNG, B.SC., AND D. H. TOMPSETT, B.SC.(ENG.)
Short-Circuit Forces on Turbo-Alternator End-Windings (PAPER NO. 1683 S, JULY, 1954)

Digest not yet published
D. ANTRICH, B.SC.(ENG.), H. W. B. GARDINER, B.SC.(ENG.), AND R. K. HILTON, B.SC.(ENG.)
Supervisory Equipment for the Indication of Shaft Distortion in Steam Turbines (PAPER NO. 1622 S, APRIL, 1954)

Digest not yet published
J. L. ASHWORTH, J. S. HALL, B.SC.TECH., AND A. H. GRAY, M.SC.
The Electrical Measurement of Steam-Turbine Rotor Movements, with special reference to the Operation and Design of Modern Power Plant (PAPER NO. 1680 S, SEPTEMBER, 1954)

Written discussion on **Electricity in Medicine**

Mersey and North Wales Centre: Chairman's Address

April 1955
J. A. BROUGHALL, B.SC.(ENG.), AND K. J. COOK, O.B.E.
The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways (PAPER NO. 1744, OCTOBER, 1954)

January 1955
J. G. BRUCE, B.SC.
The Overhaul and Maintenance of Direct-Current Traction Motors (PAPER NO. 1723, NOVEMBER, 1954)

Discussion on **The Uses of Earthed Signal Conductors on Transmission Circuits before the North Midland Centre**

February 1955
PROFESSOR F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., AND E. R. LAITHWAITE, M.SC.
A Brushless Variable-Speed Induction Motor (PAPER NO. 1737 U, NOVEMBER, 1954)

Written discussion on **Transient Behaviour of Ladder Networks of the Type representing Transformer and Machine Windings**

Discussion on **Fluorescent Discharge-Tube Circuits and Operating Problems** before the North-Western Utilization Group, the Northern Ireland Centre and the North Midland Utilization Group

Digest not yet published
C. J. BEAVIS
The Use of Electricity in the Production of Calcium Carbide (PAPER NO. 1721 U, OCTOBER, 1954)

Discussion on **Voltage Transformers and Current Transformers associated with Switchgear** before the South-East Scotland Sub-Centre and the North Midland Centre

Discussion on **Post-Graduate Activities in Electrical Engineering** before the North Midland Centre, the South Midland Centre, the Southern Centre and the North-Eastern Centre

Discussion on **Domestic Electrical Installations—Some Safety Aspects** before the Southern Centre, the North-Eastern Centre, the East Midland Centre, the South Midland Centre, the North-Western Centre, the South-Western Sub-Centre, the North Midland Utilization Group, the South-East Scotland Sub-Centre, the Mersey and North Wales Centre, the Western Centre, Tees-Side Sub-Centre, the Sheffield Sub-Centre and the North Staffordshire Sub-Centre

Discussion on **Insulation of Rotating Electrical Machinery** before the South-East Scotland Sub-Centre

Discussion on **The Co-ordination of Insulation of High-Voltage Electrical Installations** before the South Midland Centre, the Irish Branch, the North Staffordshire Sub-Centre, the North-Western Centre, the North-Eastern Centre and the Mersey and North Wales Centre

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	MERVIN J. KELLY, PH.D., D.ENG., D.SC., LL.D., SIR GORDON RADLEY, C.B.E., PH.D.(ENG.), G. W. GILMAN, M.S., AND R. L. HALSEY, B.SC.(ENG.)
January 1955	**A Transatlantic Telephone Cable** (PAPER NO. 1741, SEPTEMBER, 1954)
	Discussion on **Post-Graduate Activities in Electrical Engineering** before the North Midland Centre, the South Midland Centre, the Southern Centre, and the North-Eastern Centre
	Local Centre and Sub-Centre Chairmen's Addresses
	Discussion on **A Survey of Electrical Ceramics** before the South-West Scotland Sub-Centre
	J. MCA. STEELE, B.SC.(ENG.)
February 1955	**The Standard Frequency Monitor at the National Physical Laboratory** (PAPER NO. 1765 M, OCTOBER, 1954)
Digest not yet published	H. B. LAW, B.SC.TECH. **Standard Frequency Transmission Equipment at Rugby Radio Station** (PAPER NO. 1762 R, OCTOBER, 1954)
	Discussion on the **above two papers** and on **Standard Frequency Transmissions** before the Radio and Measurements Sections
	PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.)
February 1955	**The Application of the Hall Effect in a Semi-Conductor to the Measurement of Power in an Electromagnetic Field** (PAPER NO. 1654 M, JUNE, 1954)
	PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.)
February 1955	**The Design of Semi-Conductor Wattmeters for Power-Frequency and Audio-Frequency Applications** (PAPER NO. 1778 M, NOVEMBER, 1954)
	A. H. M. ARNOLD, PH.D., D.ENG.
February 1955	**Audio-Frequency Power Measurements by Dynamometer Wattmeters** (PAPER NO. 1653 M, APRIL, 1954)
	Discussion on the **above three papers** before the Measurements Section
	N. L. YATES-FISH, M.A., D.PHIL., AND E. FITCH, B.SC.
April 1955	**Signal/Noise Ratio in Pulse Code Modulation** (PAPER NO. 1776 R)
	W. A. JOHNSON, M.A.
April 1955	**The Notch Aerial and some Applications to Aircraft Radio Installations** (PAPER NO. 1742 R)
Digest not yet published	A. F. HARVEY, D.PHIL., B.SC.(ENG.) **A Surface-Texture Comparator for Microwave Structures** (PAPER NO. 1756 R)
Digest not yet published	A. F. HARVEY, D.PHIL., B.SC.(ENG.) **The Electroforming of Components and Instruments for Millimetre Wavelengths** (PAPER NO. 1757 R)
Digest not yet published	E. F. STACK-FORSYTH, B.SC., PH.D. **An Experimental Study of the Propagation of 10 cm Radio Waves over a Short Non-Optical Sea Path** (PAPER NO. 1780 R)
Digest not yet published	G. J. RICH, M.SC. **The Launching of a Plane Surface Wave** (PAPER NO. 1783 R)
Digest not yet published	A. E. BARRINGTON, PH.D., B.SC. **Cold Measurements of 8 mm Magnetron Frequency and Pulling Figure** (PAPER NO. 1792 R)
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	Discussion on **Electronic Telephone Exchanges** before the Mersey and North Wales Centre
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	Written discussion on **Reception of an F.M. Signal in the Presence of a Stronger Signal in the same Frequency Band, and other Associated Results**
	Digests of Institution Monographs:
	J. M. C. DUKES, M.A. **The Effect of Severe Amplitude Limitation on certain types of Random Signal: a Clue to the Intelligibility of "Infinitely" Clipped Speech** (MONOGRAPH NO. 111 R, NOVEMBER, 1954)
	J. L. FARRANDS, PH.D., B.SC. **The Generation of Millimetre Waves** (MONOGRAPH NO. 112 R, DECEMBER, 1954)

PART C. MONOGRAPHS (MARCH, 1955)

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